

PEARSON EDEXCEL IAL BIOLOGY • YBI11

# BIOLOGY



**EXAM QUESTION PACK**

**UNIT 4: MICROBIOLOGY, IMMUNITY AND FORENSICS**

**SCORE**

**/452**

**PERCENTAGE**

**%**

**STEMUP**

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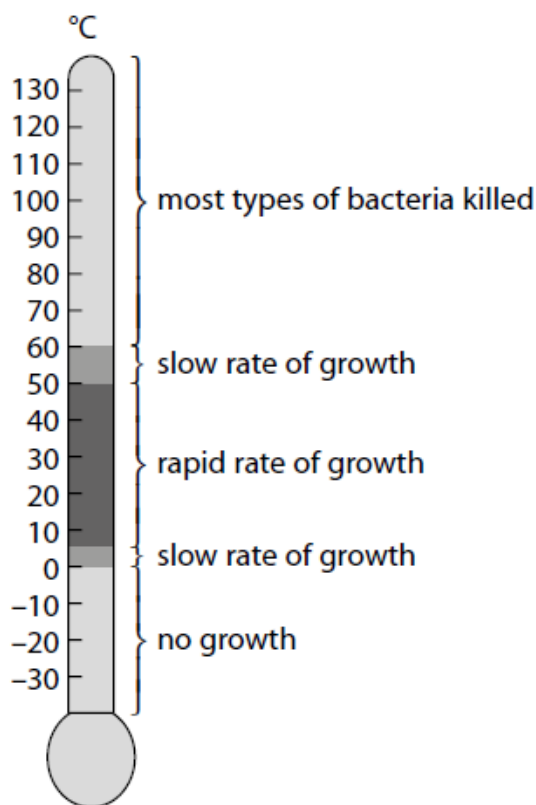
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Q1.

Temperature affects the rate of growth of bacteria.

The diagram shows some information about the growth of bacteria in different ranges of temperature.



(a) Explain why most types of bacteria are killed at temperatures above 60 °C, but bacteria can grow slowly in a temperature range of 50 °C to 60 °C.

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(b) (i) The growth rate constant will be at its highest in the temperature range of 5 °C to 50 °C.

Calculate the growth rate constant ( $k$ ) of bacteria that have increased from  $5 \times 10^3$  cells per  $\text{cm}^3$  to  $1.3 \times 10^5$  cells per  $\text{cm}^3$  in 4 hours.

(3)

$$k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$$

Answer .....

(ii) The formula used to calculate the growth rate constant can only be applied to one phase of bacterial growth.

To which phase of bacterial growth can the formula be applied?

(1)

- ☐ **A** death
- ☐ **B** exponential
- ☐ **C** lag
- ☐ **D** stationary

(c) (i) Explain why some foods are kept in refrigerators at a temperature between 0 °C and 5 °C.

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(ii) Explain why there is no growth of bacteria in a freezer at a temperature of –18 °C.

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**(Total for question = 13 marks)**

Q2.

Human serum albumin is a globular protein found in blood plasma.

Albumin has a molecular mass of 66 300 daltons.

It consists of 585 amino acids.

At pH 7.4 albumin has over 200 negative charges on the surface of each molecule.

(a) (i) Calculate the mean molecular mass of an amino acid in albumin.

Give your answer to an appropriate number of significant figures.

**(1)**

Answer ..... daltons

(ii) Explain why albumin is soluble in blood plasma.

**(2)**

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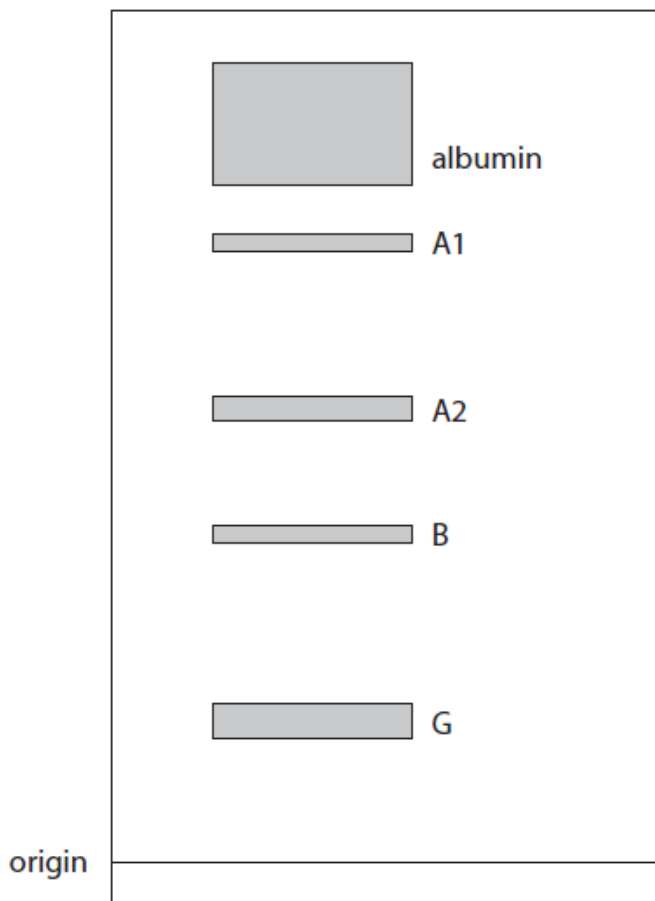
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(b) Albumin can be separated from other proteins in blood plasma, A1, A2, B and G, by gel electrophoresis.

The diagram shows the banding pattern produced on separation of these proteins by gel electrophoresis.



(i) Protein G has a concentration in blood plasma in the range  $0.700 \text{ g dm}^{-3}$  to  $1.700 \text{ g dm}^{-3}$ .

Albumin has a concentration in blood plasma in the range  $0.525 \text{ g dm}^{-3}$  to  $1.275 \text{ g dm}^{-3}$ .

Calculate the maximum difference in the concentration of these two proteins.

(1)

Answer .....  $\text{g dm}^{-3}$

(ii) Describe the conclusions that can be made about albumin, compared with the other four proteins present in blood plasma.

Use the information in the diagram to support your answer.

(3)

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(c) Albumin binds to and activates a proton channel, hHv1.

This proton channel is present in the membranes of sperm cells. When the channel is activated, sperm cells have the ability to penetrate and fertilise egg cells.

Sperm cells are released in a liquid called seminal fluid. Seminal fluid has an albumin concentration of  $15 \mu\text{mol dm}^{-3}$ .

The fluid inside the uterus of the female has an albumin concentration of  $500 \mu\text{mol dm}^{-3}$ .

Explain the role of albumin concentration in controlling fertilisation.

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**(Total for question = 11 marks)**

Q3.

Patients with cystic fibrosis may develop serious bacterial infections.

A patient with cystic fibrosis developed bacterial infections including *Mycobacterium*.

(a) (i) This patient was given a combination of antibiotics for several months.

Explain why a combination of antibiotics had to be given for several months.

(2)

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(ii) This patient did not respond to the combination of antibiotics, and later needed a lung transplant.

Suggest why this patient needed a lung transplant.

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(iii) Following the transplant, the patient was given immunosuppressive drugs.

Immunosuppressive drugs weaken the immune system. Some of these drugs work by preventing DNA synthesis in the patient.

As a result of the immunosuppressive drug treatment, the infection with *Mycobacterium* developed faster.

Explain why the infection with *Mycobacterium* developed faster when the patient was taking immunosuppressive drugs.

(4)

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Phages are viruses that target bacterial cells.

Number of bacteria

Number of phages

Time

Start of phage therapy

Key

- bacteria
- - - phages

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Use the information in the graph to support your answer.

(6)

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**(Total for question = 15 marks)**

Q4.

Madagascar is a large island off the southeast coast of mainland Africa.

Lemurs are endemic to Madagascar.

(a) There are many different species of lemur, all of which evolved from one common ancestor.

This common ancestor is thought to be a primate that was carried across the sea from mainland Africa on a raft of vegetation.

The photographs show two different species of lemur, Sifaka and Indri, found in the same region of Madagascar.



Sifaka



Indri

The diet of Sifakas is mostly seeds but also includes fruits, flowers and some types of leaves. The diet of Indri is mainly leaves.

Explain the types of speciation that have taken place in the evolution of Sifakas and Indri in this region of Madagascar.

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(b) Lemurs have been found on another island close to Madagascar.

Scientists have used DNA profiling to show that these lemurs originated from those on Madagascar.

(i) Explain the role of the polymerase chain reaction (PCR) in DNA profiling.

(2)

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(ii) Explain how DNA profiling could show that these lemurs originated from the lemurs on Madagascar.

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**(Total for question = 8 marks)**

Q5.

**Answer the question with a cross in the box you think is correct ☐ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐ .**

The time of death of a person can be estimated in a number of ways.

(a) The time of death can be estimated using the length of insect larvae.

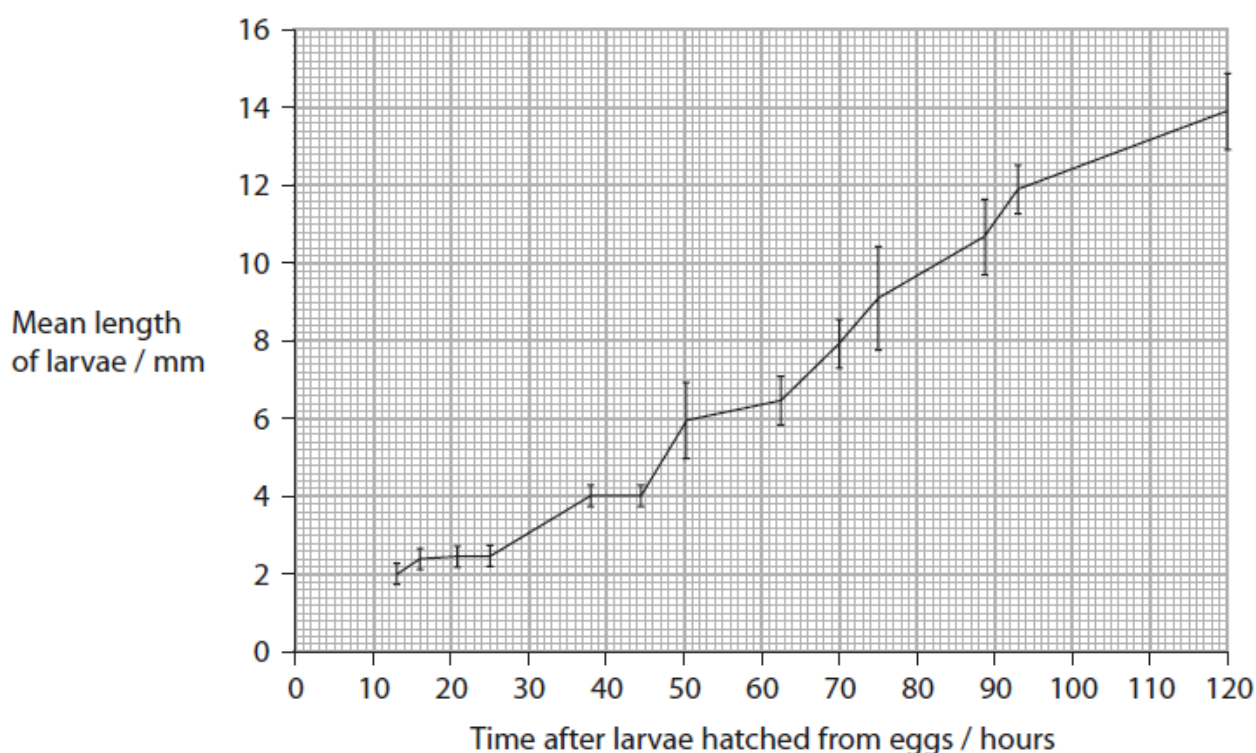
What is the name of the method that uses insect larvae to estimate the time of death?

(1)

- ☐ **A** dendrochronology
- ☐ **B** epigenetics
- ☐ **C** forensic entomology
- ☐ **D** species diversity

(b) The larvae of one species of blowfly can be used to estimate the time of death.

The graph shows the mean length of larvae from this species incubated at 10.62 °C.



(i) Calculate the mean growth rate of these larvae from 25 to 120 hours.

Include the units with your answer.

(2)

Answer. ....

(ii) Comment on the suitability of using this data to estimate the time of death.

Use the information in the graph to support your answer.

(3)

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(iii) Describe how the data shown in this graph could have been collected.

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(c) The time of death can be estimated using the body temperature of the corpse.

Evaluate the use of the body temperature of a corpse to estimate the time of death.

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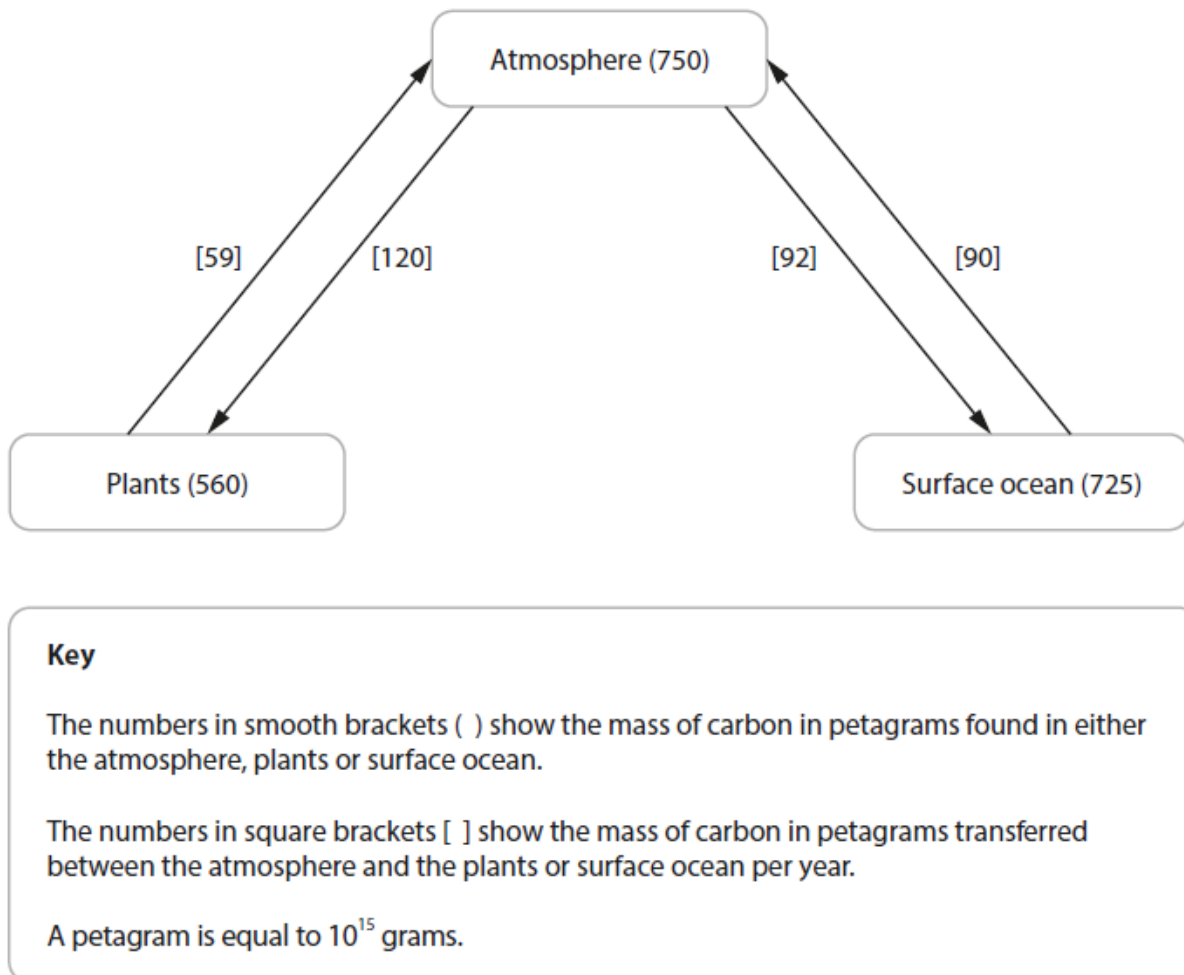
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Q6.

The diagram shows part of the carbon cycle.



(a) Carbon is found in carbohydrates.

The table shows some carbohydrates that may be found in plants and animals.

For each carbohydrate, put **one** cross ☐ in the appropriate box, in each row, to show where these carbohydrates are produced.

(4)

| Carbohydrate | Carbohydrate produced by |                          |                          |                            |
|--------------|--------------------------|--------------------------|--------------------------|----------------------------|
|              | both plants and animals  | plants but not animals   | animals but not plants   | neither plants nor animals |
| Amylose      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |
| Glucose      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |
| Glycogen     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |
| Starch       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |

(b) The mass of carbon recycling between the atmosphere and the plants, and the atmosphere and the oceans, are roughly balanced.

(i) State how carbon is exchanged between the atmosphere and the oceans.

(1)

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(ii) Calculate the increase in the mass of carbon in plants as a result of carbon exchange between the plants and the atmosphere in one year.

Give your answer in kilograms.

(1)

Answer ..... kg

(iii) Describe how the carbon present in sugars in the plants is returned to the atmosphere in the carbon cycle.

(3)

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(c) Anthropogenic climate change is a result of an increase in the mass of carbon in the atmosphere.

(i) State what is meant by the term **anthropogenic climate change**.

(2)

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(ii) Explain **one** way in which the effects of anthropogenic climate change can be reduced.

(2)

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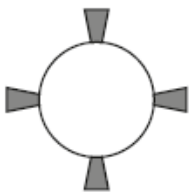
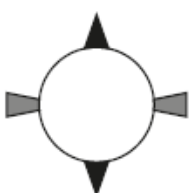
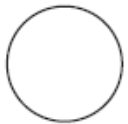
**(Total for question = 13 marks)**

Q7.

Humans can have one of four different blood types: A, B, AB or O.

Blood type is determined by antigens present on the membranes of red blood cells.

The table shows which antigens are present in each blood type.

| Blood type | Antigens on the membrane of red blood cells | Diagram of one red blood cell                                                       |
|------------|---------------------------------------------|-------------------------------------------------------------------------------------|
| A          | antigen A only                              |   |
| B          | antigen B only                              |   |
| AB         | both antigens A and B                       |   |
| O          | neither antigen A nor B                     |  |

Blood transfusions are used in the treatment of some diseases.

A blood transfusion involves taking blood from a healthy person and putting it into the person needing the treatment.

(a) (i) Which blood type can be used for all blood transfusions?

(1)

- ☐ **A** blood type A
- ☐ **B** blood type B
- ☐ **C** blood type AB
- ☐ **D** blood type O

(ii) Explain what will happen if a person with blood type A is given a transfusion of blood type AB.

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(b) Bacteria live in our intestines (gut flora).

The membranes of cells lining our intestines have molecules similar to the antigens on red blood cells.

(i) Explain why bacteria living in our intestines are important.

(2)

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(ii) Both the molecules on the membranes of the cells lining our intestines and the antigens on red blood cells have  
sugars attached to protein molecules.

Bacteria living in our intestines secrete an enzyme that separates the sugars from the protein molecules.

Suggest why bacteria living in our intestines secrete this enzyme.

(2)

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(iii) Explain why this enzyme may be useful in blood transfusions.

(2)

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(Total for question = 11 marks)

Q8.

**Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒ .**

There are four types of immunity.

(a) Artificial immunity develops when a person is immunised by an injection.

The table gives some statements about artificial immunity.

For each statement, put **one** cross ☒ in the appropriate box, in each row, to show which statements are correct for the types of artificial immunity.

(3)

| Statement                               | Type of artificial immunity |                          |                          |                            |
|-----------------------------------------|-----------------------------|--------------------------|--------------------------|----------------------------|
|                                         | both active and passive     | active only              | passive only             | neither active nor passive |
| Antibodies are injected into the person | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |
| B cells differentiate into plasma cells | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |
| Memory cells are formed                 | <input type="checkbox"/>    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>   |

(b) Natural active immunity can develop when a person is infected with a virus.

(i) Describe the role of macrophages in the development of natural active immunity to a virus, following infection.

(3)

(ii) Explain why both T helper cells and T killer cells are needed in the immune response to a virus.

(4)

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**(Total for question = 10 marks)**

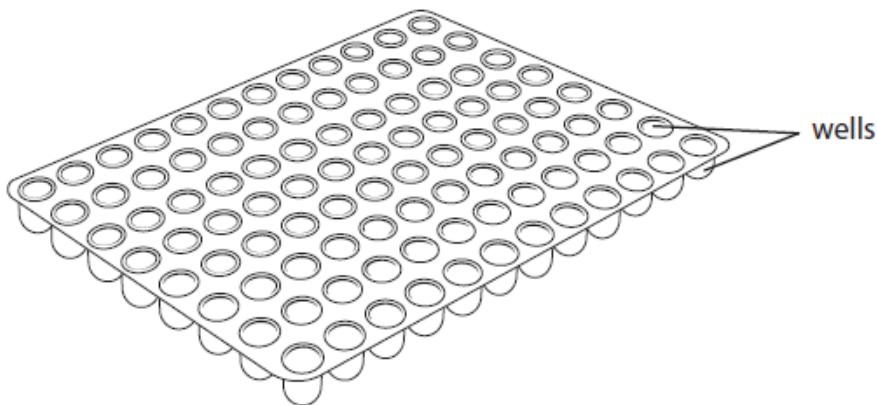
Q9.

Antimicrobial substances can be tested using a Minimum Inhibitory Concentration (MIC) assay.

This assay determines the lowest concentration of an antimicrobial substance that prevents visible growth of bacteria.

A microdilution plate is used in these assays. It is made of plastic and contains small wells that the antimicrobial substance and the bacteria can be added to.

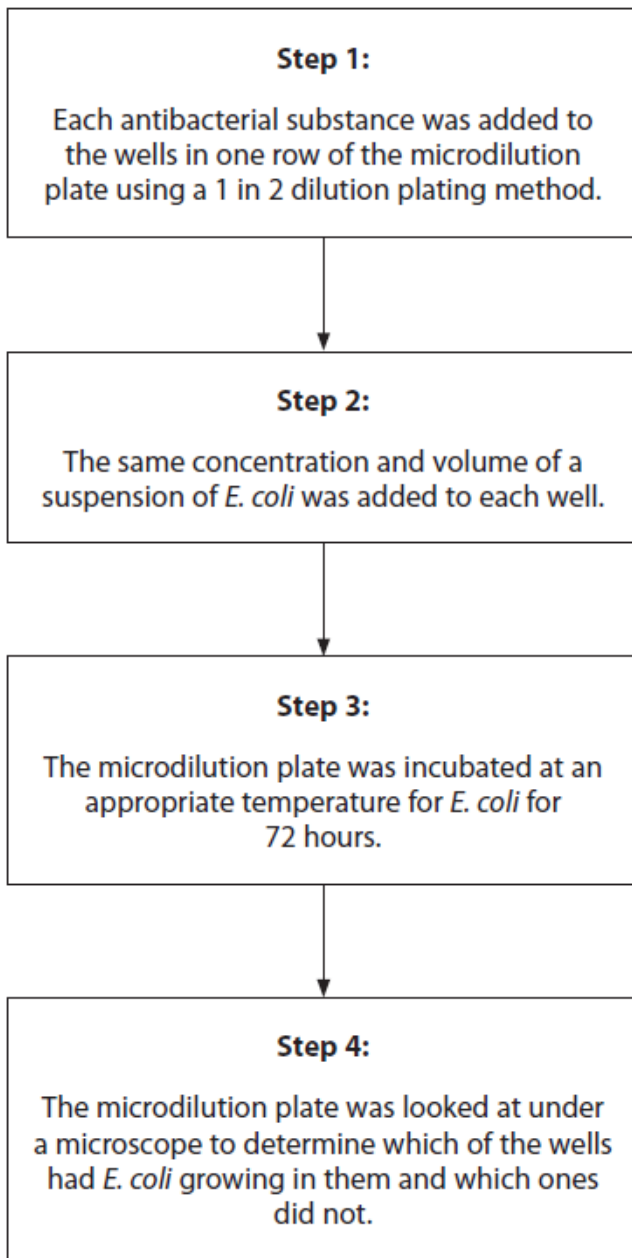
The diagram shows a microdilution plate.



An investigation tested eight antimicrobial substances on one type of bacteria, *E. coli*.

Appropriate controls were included in this investigation.

The diagram shows the steps involved.



(a) All steps in this investigation had to be carried out using aseptic technique.

(i) State the meaning of the term **aseptic technique**.

(1)

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(ii) Describe two aseptic techniques that could be used in this investigation.

(2)

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(iii) Explain why using aseptic technique in this investigation is important.

(2)

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(b) Explain why the microdilution plate had to be incubated at an appropriate temperature for *E. coli* for 72 hours.

(2)

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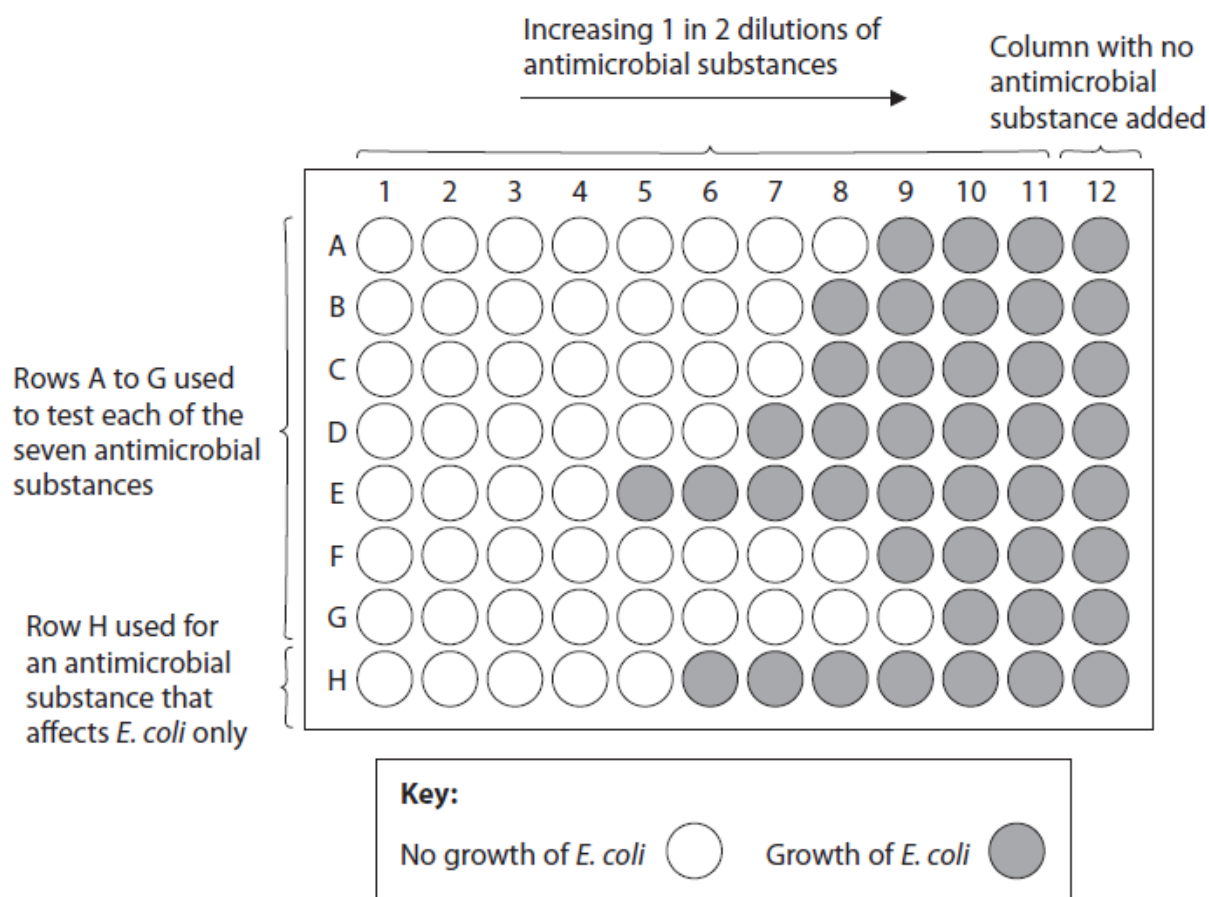
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(c) The diagram shows the results of the MIC assay from this investigation.



(i) Explain why an antimicrobial substance that affects *E. coli* only was included in this assay (row **H**).

(2)

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(ii) Explain why there was one column that had no antimicrobial substance added to it (column 12).

(2)

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(iii) The MIC for the antimicrobial substance used in row **E** was in column 4.

Describe how a 1 in 2 dilution plating method would have been carried out to achieve the dilution in this well.

(2)

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(iv) Calculate how many times more effective the antimicrobial substance used in row **G** is than the antimicrobial substance used in row **E**.

(2)

Answer .....

**(Total for question = 15 marks)**

Q10.

**Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).**

A student grew a bacterial culture in a liquid medium for 20 hours.

Every hour, a sample of the culture was removed.

This sample was added to some fresh medium and mixed thoroughly.

This mixture was spread onto agar in a Petri dish, so that the number of bacteria in the culture could be determined.

(a) Which method is being used to determine the number of bacteria in this culture?

(1)

- ☐ **A** dilution plating
- ☐ **B** latency
- ☐ **C** mass method
- ☐ **D** optical method (turbidity)

(b) Explain how the Petri dish should have been sealed after the mixture was spread onto the agar.

(2)

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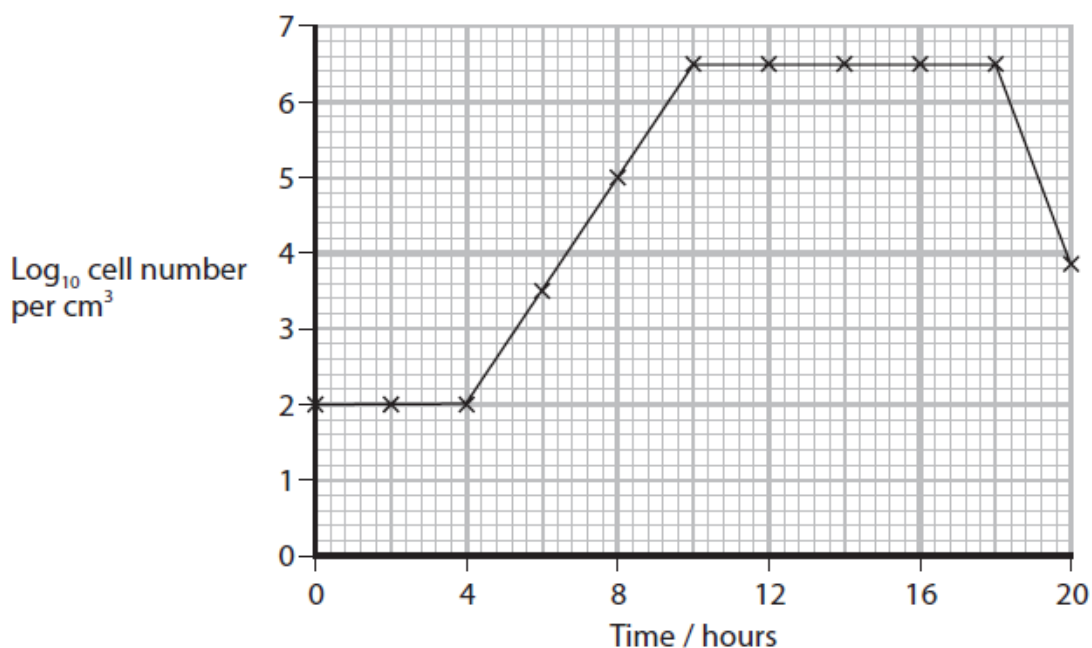
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(c) The graph shows the bacterial growth curve for this culture.



(i) Which shows the order of the phases of a bacterial growth curve?

(1)

- ☐ **A** exponential → lag → death → stationary
- ☐ **B** lag → stationary → death → exponential
- ☐ **C** lag → exponential → stationary → death
- ☐ **D** stationary → exponential → lag → death

(ii) The bacteria were not growing at their fastest rate in the conditions the student used.

How many of the following changes could result in a faster growth rate?

- decrease in pH
- decrease in temperature
- increase in pH
- increase in temperature

(1)

☐ A 1

☐ B 2

☐ C 3

☐ D 4

(iii) Calculate the growth rate constant (k) of these bacteria between 4 hours and 10 hours.

(2)

Use the equation:  $k = \frac{\log_{10} N_t - \log_{10} N_0}{0.301 \times t}$

Give your answer to two decimal places.

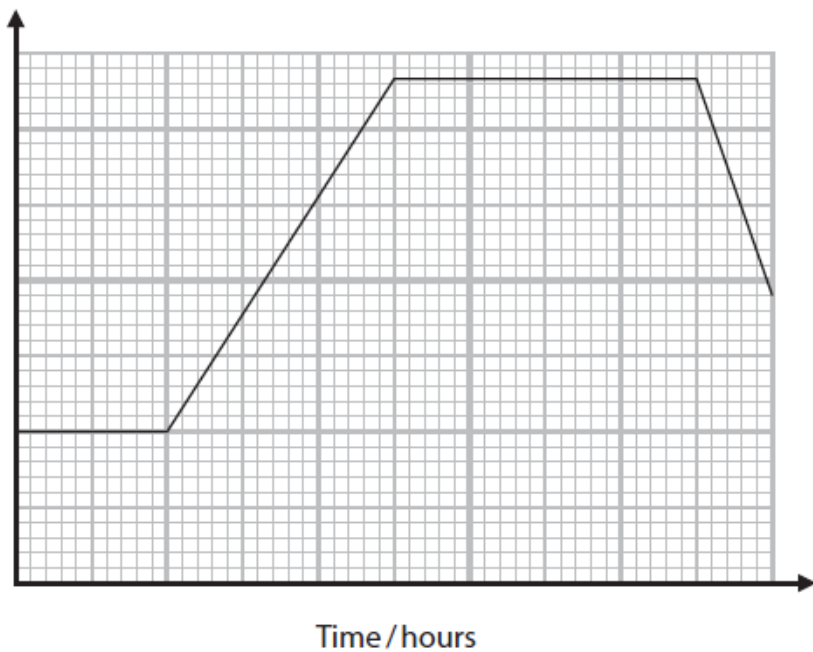
Answer .....

**(Total for question = 7 marks)**

Q11.

**Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

The graph shows a bacterial growth curve, produced by counting the number of bacterial colonies using the dilution plating technique.



(a) Which label should be used for the y-axis of this graph?

(1)

- ☐ **A**  $\log_{10}$  number of living bacterial cells
- ☐ **B**  $\log_{10}$  total number of bacterial cells
- ☐ **C** number of living bacterial cells
- ☐ **D** total number of bacterial cells

(b) When culturing microorganisms, it is important that an aseptic technique is used.

(i) Explain the importance of using an aseptic technique.

(2)

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(ii) Explain **two** aseptic techniques that should be used in dilution plating.

(2)

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(Total for question = 5 marks)

Q12.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

Bacteriostatic and bactericidal antibiotics are used to treat bacterial infections.

(a) Give the meaning of the term **bactericidal antibiotic**.

(1)

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(b) State why antibiotics affect bacteria and usually not the person taking them.

(1)

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(c) Codes of practice advise doctors and patients about the use of antibiotics.

Describe **two** pieces of advice given to patients.

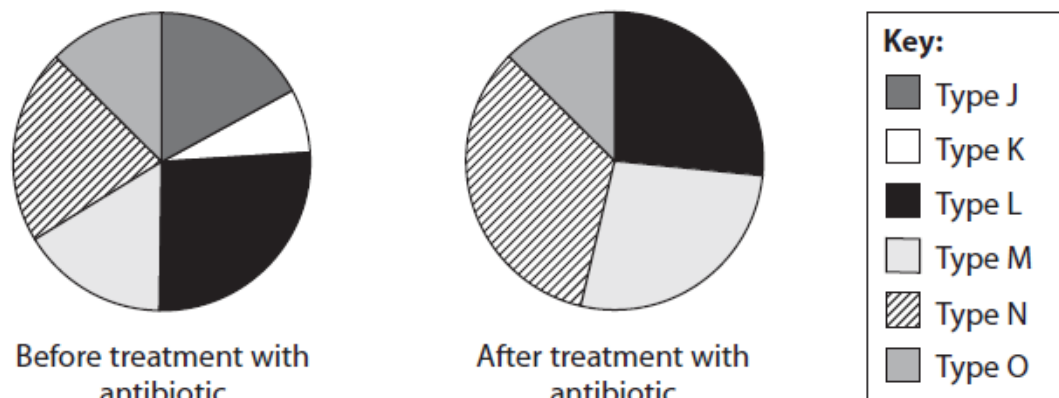
(2)

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(d) The charts show the types of bacteria present in the throat of a patient, before and after treatment with an antibiotic.



Describe the effects of this antibiotic on the bacteria present in the throat.

(3)

**(Total for question = 7 marks)**

Q13.

Climate change is dependent on the balance of carbon released into the atmosphere and carbon removed from the atmosphere.

Some ecosystems are better than others at storing carbon in their soil, releasing less back into the atmosphere.

Conserving these ecosystems could be an important way of reducing climate change.

One study investigated the extent of decomposition in different ecosystems.

This study used tea in teabags as the source of organic matter for decomposition.

The photograph shows a teabag.



(Source: © Hugh Threlfall / Alamy Stock Photo)

(a) The first part of the study was carried out in a laboratory.

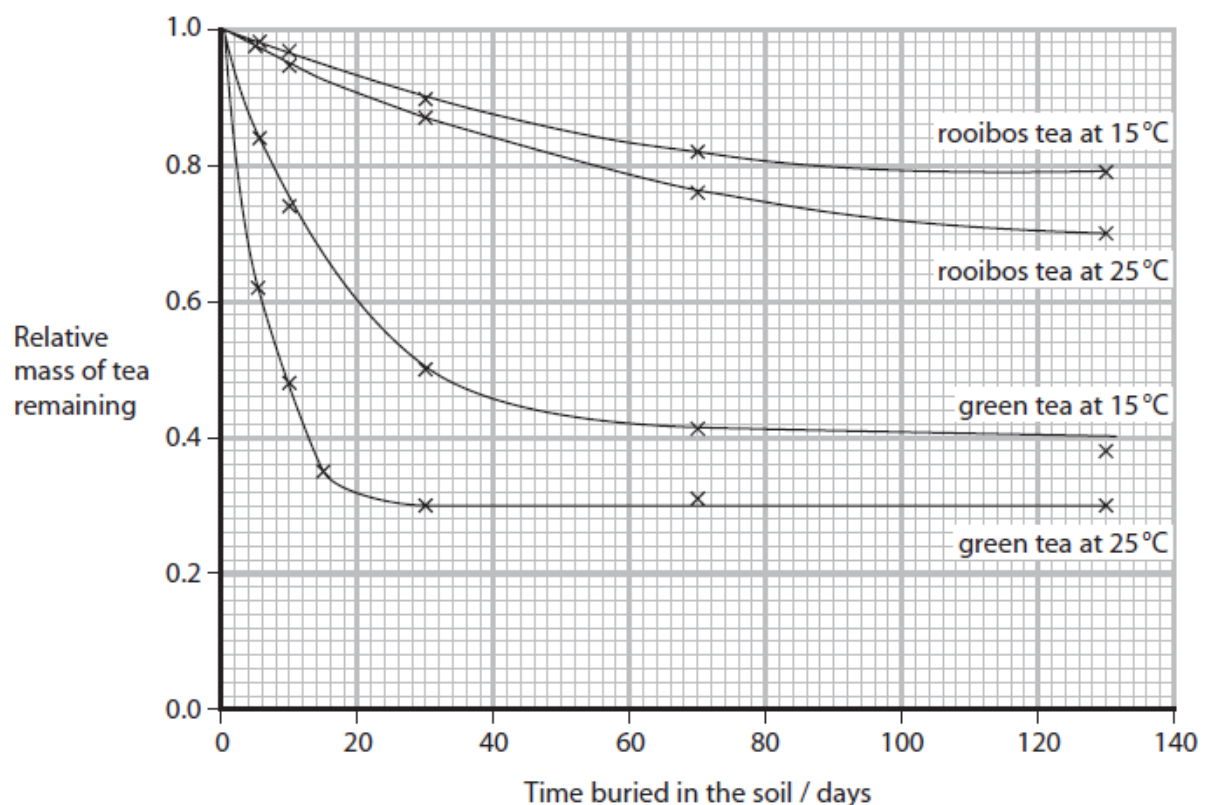
Two types of tea were used, green tea and rooibos tea.

A number of unused teabags containing each type of tea were buried in soil at two different temperatures, 15 °C and 25 °C.

The mass of tea in each teabag had been determined before they were buried.

At regular intervals teabags were dug up, dried, and the remaining tea reweighed.

The graph shows the results of this study.



(i) The teabags had to be dried before weighing to remove water.

One teabag contained 28 g of tea when it was buried. When it was dug up it had a wet mass of 42 g. The water content of this teabag was calculated to be 50 %.

Calculate the mass of organic matter lost during this study.

(1)

Answer ..... g

(ii) Calculate the rate at which the relative mass of the green tea decreases in the teabags buried at 15 °C at day 30.

(2)

Answer .....

(iii) Explain the difference in the decrease in relative mass of green tea in teabags buried at 15 °C and 25 °C.

Use the information in the graph to support your answer.

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(iv) Suggest why the rate of decomposition of green tea was different from that of rooibos tea.

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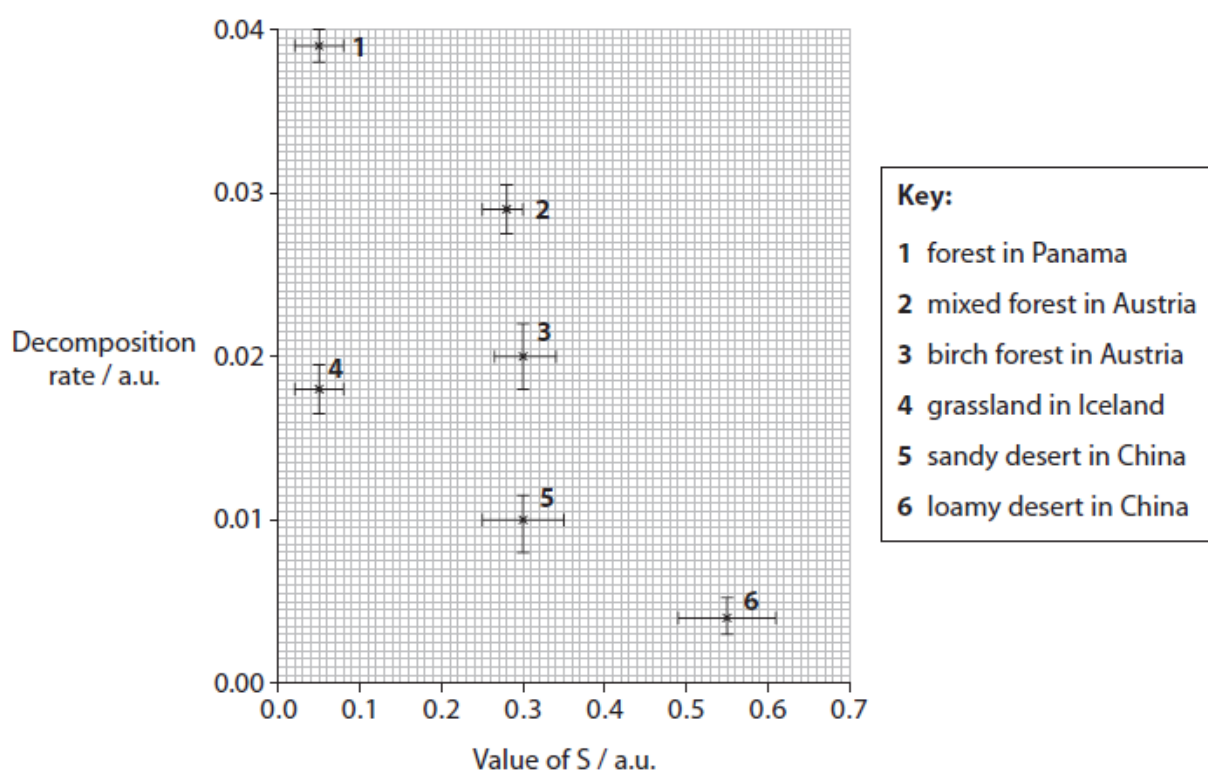
(b) In the second part of this study, several teabags were buried in different ecosystems.

The teabags were left buried for three months and then dug up.

A number of measurements were taken from the tea in these teabags and the mean decomposition rate and the mean stabilisation factor (S) calculated.

The higher the value of S, the more carbon is stored in the ecosystem.

The graph shows some of the results from this study.



(i) Suggest why each point on the graph has both a horizontal and a vertical error bar plotted with it.

(1)

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(ii) Explain which ecosystems should be conserved to have the greatest impact on climate change.

Use the information in the graph to support your answer.

(3)

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(Total for question = 13 marks)

Q14.

Body temperature and the degree of muscle contraction can be used to determine the time since death of a person.

The table shows how body temperature and body stiffness, due to muscle contraction, change with time since death.

| Time since death / hours | Body temperature | Body stiffness |
|--------------------------|------------------|----------------|
| < 3                      | warm             | not stiff      |
| 3 to 8                   | warm             | stiff          |
| 8 to 36                  | cold             | stiff          |
| > 36                     | cold             | not stiff      |

(a) State how the temperature of a dead body should be measured.

(1)

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(b) (i) Body temperature can be used to estimate the time since death using the following information:

- loss of  $0.78^{\circ}\text{C}$  per hour for the first 12 hours after death
- after 12 hours, loss of  $0.4^{\circ}\text{C}$  per hour.

Estimate the time since death of a person whose body temperature had fallen  $11.5^{\circ}\text{C}$ .

Give your answer to the nearest hour.

(2)

Answer ..... hours

(ii) Explain why this estimate would be different if the body had been left in a colder place.

(2)

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(c) Explain why using body stiffness only, as shown in the table, is insufficient to estimate the time since death accurately.

(3)

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(Total for question = 8 marks)

Q15.

Alzheimer's disease is a cause of dementia in older people.

The neurones in the brain are damaged and eventually destroyed.

Abnormal plaques are seen in the brains of people with Alzheimer's disease. These plaques are made of a protein called  $\beta$ -amyloid.

Drug ATD is a new drug used to treat people with Alzheimer's disease.

This drug is an antibody that is specific for  $\beta$ -amyloid.

(a) Drug ATD was recently approved for the treatment of Alzheimer's disease.

Describe the information that had to be collected by scientists before this drug could be approved.

(3)

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(b) (i) Explain the phrase: 'an antibody that is specific for  $\beta$ -amyloid'.

(2)

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(ii) Drug ATD reduces the build-up of  $\beta$ -amyloid in the brains of people with Alzheimer's disease. Suggest how drug ATD could result in the reduction of the build-up of  $\beta$ -amyloid.

(3)

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(c) Drug ATD was derived from a B memory cell taken from an elderly person who showed no signs of Alzheimer's disease.

(i) Suggest why this person did not have Alzheimer's disease.

(2)

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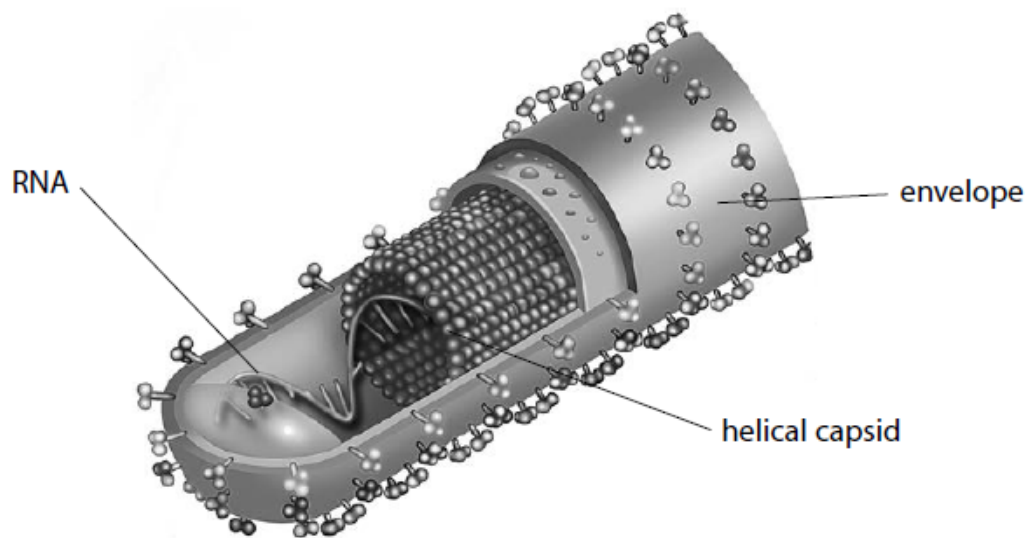
(ii) Explain why this drug could be produced only from B memory cells taken from a person who did not have Alzheimer's disease.

(2)

(Total for question = 12 marks)

Q16.

(a) The diagram shows the structure of an Ebola virus.



© Science History Images / Alamy Stock Photo

(i) Which of the following viruses contain the same type of nucleic acid as the Ebola virus?

(1)

- ☐ **A** human immunodeficiency virus (HIV) only
- ☐ **B** human immunodeficiency virus (HIV) and tobacco mosaic virus (TMV)
- ☐ **C** lambda phage ( $\lambda$  phage) only
- ☐ **D** lambda phage ( $\lambda$  phage) and tobacco mosaic virus (TMV)

(ii) Which of the following viruses have a helical capsid?

(1)

- ☐ **A** human immunodeficiency virus (HIV) and lambda phage ( $\lambda$  phage)
- ☐ **B** human immunodeficiency virus (HIV) only
- ☐ **C** lambda phage ( $\lambda$  phage) and tobacco mosaic virus (TMV)

☐ **D** tobacco mosaic virus (TMV) only

(iii) What type of molecule makes up the capsid of a virus?

(1)

☐ **A** carbohydrate

☐ **B** lipid

☐ **C** nucleic acid

☐ **D** protein

(iv) The volume of an Ebola virus is approximately  $7.76 \times 10^4 \text{ nm}^3$ .

Tobacco mosaic virus (TMV) is approximately 300 nm long and 80 nm in diameter.

Calculate how many times larger Ebola virus is than TMV.

Assume that TMV is a cylinder in shape.

The volume of a cylinder is calculated using the formula

$$V = \pi r^2 l$$

(2)

Answer .....

(b) Human immunodeficiency virus (HIV) contains two enzymes that are **not** found in most other types of virus.

(i) Name these two enzymes.

(1)

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(ii) Explain why HIV contains these two enzymes.

(3)

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**(Total for question = 9 marks)**

Q17.

The photograph shows a regent honeyeater.



(Source: © Dave Watts / Alamy Stock Photo)

(a) Regent honeyeaters are critically endangered, with fewer than 300 birds left in the wild.

A study found that a large proportion of the male birds no longer sing the characteristic songs of their own species.

Some of the birds had learnt the songs of other species.

(i) Suggest why a large proportion of these male birds no longer sing the characteristic songs of regent honeyeaters.

**(1)**

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(ii) Explain the effect that this could have on the future of this species.

**(3)**

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(iii) Suggest how zoos could increase the number of birds in the wild that can sing the songs characteristic of this species.

(2)

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(b) Genetic studies indicate that the regent honeyeater is related to wattlebills.  
Describe how genetic studies could show this.

(4)

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(Total for question = 10 marks)

Q18.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

The table shows the energy content in the three trophic levels of a food chain from an African plain.

| Trophic level | Organism                                                                                               | Energy content |
|---------------|--------------------------------------------------------------------------------------------------------|----------------|
| 3             | <div>Lion</div>     | 920            |
| 2             | <div>Gerenuk</div>  | 8825           |
| 1             | <div>Tree</div>     | 90480          |

(a) (i) Which are the units for the energy content of these organisms?

(1)

☐ **A**  $\text{kJ m}^{-1} \text{ year}^{-1}$

☐ **B**  $\text{kJ m}^{-1} \text{ year}^{-2}$

☐ **C**  $\text{kJ m}^{-2} \text{ year}^{-1}$

☐ **D**  $\text{kJ m}^{-2} \text{ year}^{-2}$

(ii) The energy content of the tree is the net primary productivity (NPP).

What is the relationship between NPP, gross primary productivity (GPP) and respiration (R)?

(1)

☐ **A**  $\text{NPP} = \text{GPP} + \text{R}$

☐ **B**  $\text{NPP} = \text{GPP} - \text{R}$

☐ **C**  $\text{NPP} = \text{GPP} \times \text{R}$

☐ **D**  $\text{NPP} = \text{GPP} \div \text{R}$

(iii) Calculate the ratio of the energy contents shown in these trophic levels:

trophic level 1 : trophic level 2 : trophic level 3

(1)

Answer .....

(iv) Explain why there is no fourth trophic level in this food chain.

(2)

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(v) Describe the role of microorganisms in recycling carbon present in this food chain.

(3)

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\*(b) The photographs show gerenuk and a springbok to the same magnification.



gerenuk



(Source: © David Havel / Alamy Stock Photo)

springbok

The table gives some information about gerenuk and springbok.



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**(Total for question = 14 marks)**

Q19.

Forensic entomology is a method for estimating the time of death of a mammal.

(a) Seventy-two hours or more after death, forensic entomology is the most accurate method for estimating the time of death.

Forensic entomology can also provide information about the place of death and indicate if the body has been moved.

(i) Explain why forensic entomology is the most accurate method for estimating the time of death, if this is greater than 72 hours.

**(2)**

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(ii) Explain how forensic entomology can indicate if a body has been moved from the place of death.

**(2)**

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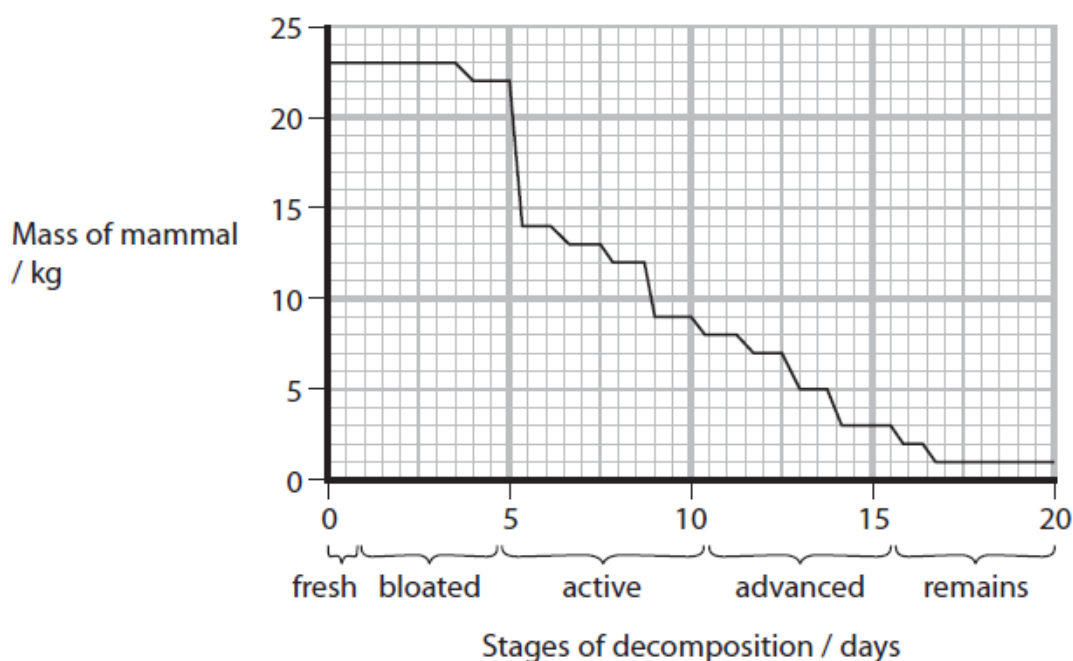
(b) A study looked at the succession of insects associated with the decomposition of a dead mammal in the Andean Coffee region.

In this study, a mammal was killed, placed inside a metal cage in this region and left until it had completely decomposed.

The body of this mammal was monitored regularly.

The stages of decomposition were identified and various measurements were taken and recorded. Insects in the different stages of their lifecycle were collected and identified.

The graph shows the changes in mass of this mammal during the decomposition period.



(i) Suggest why the mammal was placed inside a metal cage to decompose.

(1)

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(ii) Calculate the rate of change in mass between day 5 and day 15 of decomposition.

Express your answer in  $\text{kg hr}^{-1}$ .

Give your answer to two decimal places.

(2)

Answer .....  $\text{Kg hr}^{-1}$

(iii) Explain the changes in mass of this mammal during decomposition.

(4)

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(iv) Suggest why some of the insect eggs, collected from the decomposing mammal, were taken back to the laboratory and kept for a few days.

(1)

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(v) The table shows data on some of the insects collected from this decomposing mammal.

| Type of insect         | Percentage of some of the insect found at each stage of decomposition (%) |         |        |          |         |
|------------------------|---------------------------------------------------------------------------|---------|--------|----------|---------|
|                        | Fresh                                                                     | Bloated | Active | Advanced | Remains |
| <i>Lucilia</i>         | 100.0                                                                     | 61.4    | 1.8    | 3.7      | 0.0     |
| <i>Cochliomyia</i>     | 0.0                                                                       | 15.5    | 68.4   | 35.1     | 0.0     |
| <i>Chrysomya</i>       | 0.0                                                                       | 6.4     | 9.8    | 1.2      | 0.0     |
| <i>Ophyra</i>          | 0.0                                                                       | 0.0     | 0.6    | 30.9     | 83.9    |
| <i>Fannia</i>          | 0.0                                                                       | 0.0     | 0.0    | 0.1      | 0.0     |
| Other types of insects | 0.0                                                                       | 16.7    | 19.4   | 29.0     | 16.1    |

Explain how these results illustrate succession.

Use the information in the table to support your answer.

(3)

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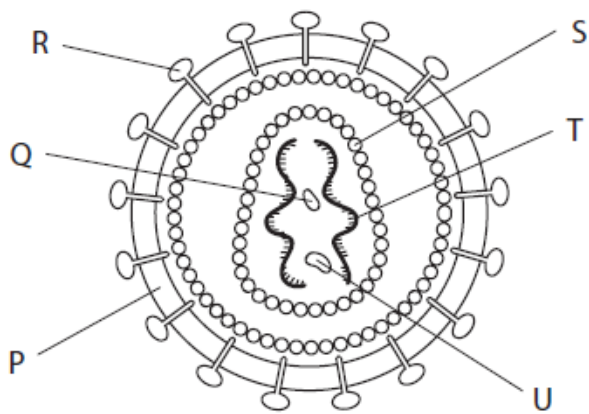
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(Total for question = 15 marks)

Q20.

Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

The diagram shows a human immunodeficiency virus (HIV).



(a) (i) Which structure is RNA?

(1)

- ☒ **A** R
- ☒ **B** Q
- ☒ **C** S

☐ **D** T

(ii) How many of the following structures contain protein?

- structure Q
- structure R
- structure S

(1)

☐ **A** 0

☐ **B** 1

☐ **C** 2

☐ **D** 3

(iii) Which virus has structure P and contains RNA?

(1)

☐ **A** Ebola virus only

☐ **B** Ebola virus and tobacco mosaic virus (TMV)

☐ **C** Tobacco mosaic virus (TMV) only

☐ **D** Neither Ebola virus nor tobacco mosaic virus (TMV)

(iv) The diameter of HIV is 120 nm.

Which is the approximate magnification of this drawing?

(1)

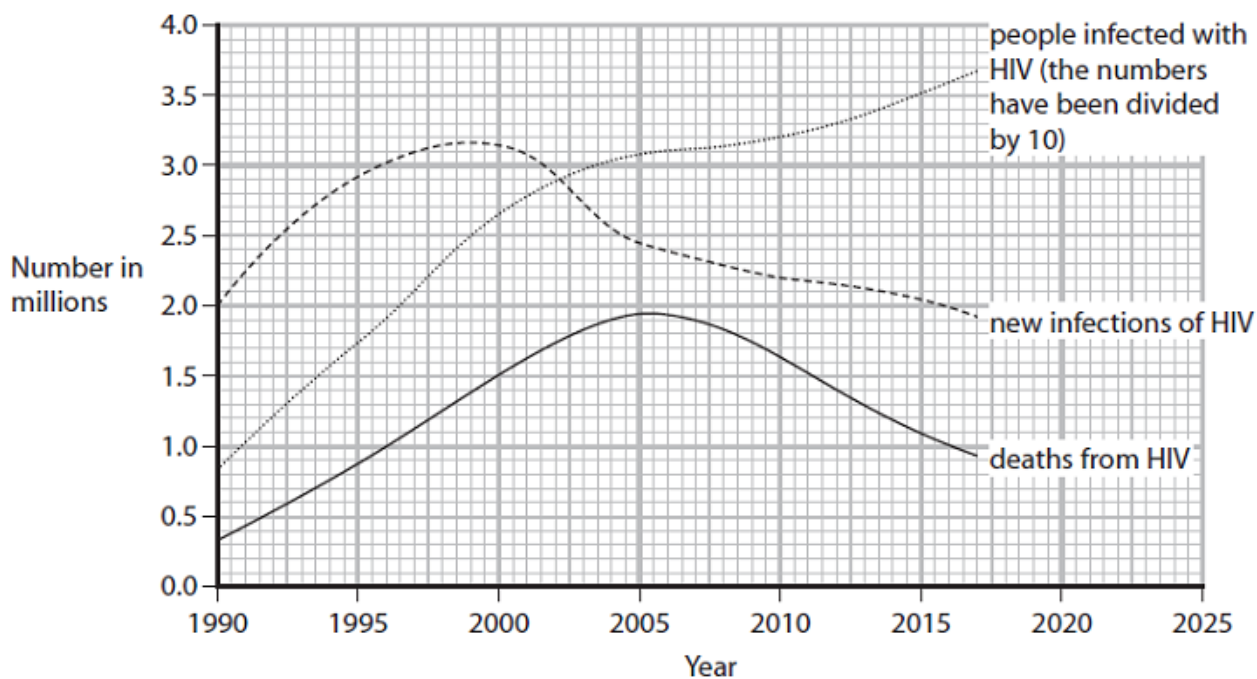
☐ **A** × 500

☐ **B** × 5 000

☐ **C** × 50 000

☐ **D** × 500 000

(b) The graph shows the number of HIV infections and the number of deaths from HIV in the world from 1990 to 2017.



(i) The data plotted for the number of people infected with HIV has been divided by 10.  
Explain why these numbers were divided by 10.

(2)

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(ii) Calculate the mean rate of increase in the number of people infected with HIV from 2005 to 2010.

Express your answer in standard form to an appropriate number of significant figures.

(2)

Answer ..... mean number of infections year<sup>-1</sup>

(iii) Explain why the number of people infected with HIV is going up although the number of new infections and deaths is going down, after 2005.

(2)

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(iv) State how the graph can be used to estimate the number of deaths in 2025.

(1)

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(v) Explain why this estimate would be lower if a vaccine for HIV became available in 2023.

(3)

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(Total for question = 14 marks)

## **Mark Scheme**

Q1.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• above 60°C the enzymes are denatured (1)</li> <li>• so there will be no metabolic reactions (1)</li> <li>• because between 50°C to 60°C the enzymes are working slowly (1)</li> <li>• because the enzymes are denaturing (1)</li> </ul> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                              | Additional guidance                                                                   | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>• <math>\log_{10}</math> of <math>5 \times 10^3</math> and <math>1.3 \times 10^5</math> stated (1)</li> <li>• denominator calculated (1)</li> <li>• answer (1)</li> </ul> <p>Example of calculation:</p> <p>3.7 and 5.1</p> <p><math>0.301 \times 4 = 1.204</math></p> <p>1 / 1.2 / 1.16</p> | <p>Allow ecf</p> <p>Award full marks for correct numerical answer without working</p> | (3)  |

| Question number | Answer        | Mark |
|-----------------|---------------|------|
| (b)(ii)         | B exponential | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                        | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• decomposition will be slower (1)</li> <li>• because the enzymes will be less active (1)</li> <li>• as there is less {heat / kinetic} energy (1)</li> </ul> | (3)  |

| Question number | Answer                                                                                                                                                                                                                          | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• cytoplasm will be frozen (1)</li> <li>• therefore enzymes and substrates will not be able to {move / collide} (1)</li> </ul> | (2)  |

Q2.

| Question number | Answer | Additional guidance | Mark |
|-----------------|--------|---------------------|------|
| (a)(i)          | • 113  |                     | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                                       | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• (albumin / R groups) {negatively charged / polar / hydrophilic} (1)</li> <li>• and will therefore dissolve in the {water / blood <u>plasma</u>} (1)</li> <li>• forms hydrogen bonds with water (1)</li> </ul> | <p>ACCEPT water / plasma is a polar solvent</p> <p>ACCEPT description of H bonds / weak bonds / Van der Waals forces</p> <p>DO NOT ACCEPT ionic bonds</p> | (2)  |

| Question number | Answer                        | Additional guidance                  | Mark |
|-----------------|-------------------------------|--------------------------------------|------|
| (b)(i)          | • 1.175 (g dm <sup>-3</sup> ) | ACCEPT 3 / 3.2 / 3.24 (times higher) | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                        | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• (thickest band) albumin is the most concentrated (in this sample) (1)</li> <li>• (moved the furthest) albumin could be the most soluble (1)</li> <li>• in the solvent used (1)</li> <li>• (moved the furthest) albumin could be the {lowest mass / lightest} (1)</li> </ul> | <p>ACCEPT more albumin present</p> <p>ACCEPT most (negatively) charged</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>15 <math>\mu\text{mol dm}^{-3}</math>. is too low to activate the channel / 500 <math>\mu\text{mol dm}^{-3}</math> will activate the channel (1)</li> <li>therefore sperm will not be activated in the {seminal fluid / male} / therefore sperm activated in the {uterus / female} (1)</li> <li>this will avoid waste of {resources / named resource} (1)</li> <li>so more {viable / healthy} sperm (1)</li> <li>so more likely fertilisation will take place (1)</li> </ul> | <p><b>ACCEPT</b> refs to high or low concentrations</p> <p><b>ACCEPT</b> fewer sperm activated / more sperm activated<br/>prevent early activation sperm<br/>can swim faster /<br/>acrosome enzymes will be released / sperm ready to digest the egg cell membrane</p> <p>e.g. energy / ATP / acrosome</p> <p><b>ACCEPT</b> successful</p> | (4)  |

Q3.

| Question number | Answer                                                                                                                                                                                                                                                                                                               | Additional guidance                                   | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------|
| (a)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>(combination of antibiotics given) because different bacteria are resistant to different antibiotics (1)</li> <li>(given for several months) to expose bacteria to high enough doses for long enough (1)</li> </ul> | <p><b>ACCEPT</b> to ensure all bacteria destroyed</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                      | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An answer that includes three of the following points:</p> <ul style="list-style-type: none"> <li>because <i>Mycobacterium</i> infects the lungs (1)</li> <li>(<i>Mycobacterium</i> infection) destroying lung tissue (1)</li> <li>therefore reduced <u>gas exchange</u> (1)</li> <li>so insufficient oxygen to meet (oxygen) demands of patient (1)</li> </ul> | <p><b>ACCEPT</b> a description e.g. necrosis</p> <p><b>IGNORE</b> breathing problems</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                         | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|------|
| (a)(iii)        | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>because if DNA synthesis cannot take place neither can <u>mitosis</u> (1)</li> <li>and therefore clonal expansion of {T cells / B cells} cannot take place(1)</li> <li>without T killer cells, host-infected cells cannot be destroyed</li> <li>without {B cells / plasma cells} there will be no antibody for opsonisation (of bacteria) (1)</li> <li>therefore macrophages cannot destroy the <i>Mycobacteria</i> (1)</li> </ul> | <p><b>ACCEPT</b> {T cells / B cells} cannot divide</p> <p><b>DO NOT ACCEPT</b> B cells release antibody</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| * (b)           | <p><b>Indicative content:</b></p> <ul style="list-style-type: none"> <li>number of bacteria still increasing at start of phage therapy (D)</li> <li>because it takes time for lytic cycle (E)</li> <li>bacteria number decrease (D)</li> <li>because cells get destroyed when viruses burst out (E)</li> <li>due to lytic cycle (E)</li> <li>virus numbers increase (D)</li> <li>because viruses replicate inside bacteria (E)</li> <li>and burst out (E)</li> </ul> | <p><b>Level 1 :</b></p> <p>1 mark = 1 comment made about the graph or viral infections</p> <p>2 marks = 3 comments made about {graph / viral infections}</p> <p><b>OR</b></p> <p>1 description and a linked explanation</p> |      |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                               |     |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|  | <ul style="list-style-type: none"> <li>virus numbers increase after bacterial numbers increase (D)</li> <li>because it takes time for synthesis of new components (E)</li> <li>virus particles decrease (D)</li> <li>because they get {engulfed / destroyed} by macrophages (E)</li> <li>cyclical increase and decrease in the number of bacteria (D)</li> <li>because not all bacteria get infected (E)</li> <li>therefore surviving bacteria reproduce and increase in number (E)</li> <li>cyclical increase and decrease in number of viruses (D)</li> <li>because macrophages cannot destroy all viruses (E)</li> <li>because viruses infect more bacteria (E)</li> <li>eventually no viruses or bacteria (D)</li> <li>because viruses destroy bacteria faster than they can reproduce (E)</li> <li>viruses have no more host cells / destroyed by macrophages (E)</li> </ul> | <p><b>Level 2 :</b></p> <p>3 marks = 2 descriptions and linked explanations</p> <p>4 marks = 3 descriptions and linked explanations</p> <p><b>Level 3 :</b></p> <p>5 marks = 4 descriptions and linked explanations that includes both virus and bacterial number changes</p> <p>6 marks = 5 descriptions and linked explanations that includes both virus and bacterial number changes + the cyclical nature of the data</p> | (6) |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|

Q4.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>allopatric speciation (1)</li> <li>(allopatric) because lemurs have the same common ancestor isolated from those in Africa (1)</li> <li>sympatric speciation (1)</li> <li>(sympatric) because Sifakas and Indri live together but have a different diet (1)</li> </ul> | <p><b>ACCEPT</b> geographic speciation</p> <p><b>ACCEPT</b> description of how diet is different</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                   | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>because only small quantities of DNA can be collected (1)</li> <li>therefore need to {amplify / increase the number of copies of} DNA(1)</li> <li>so that there is enough to {run on gel electrophoresis / analyse}</li> </ul> | <p><b>ACCEPT</b> collecting a sample is difficult</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>gel electrophoresis run on DNA from both groups of lemurs</li> <li>pattern of bands were similar showing the lemurs were genetically similar (1)</li> <li>base sequencing would show similar sequences (1)</li> </ul> | <p><b>ACCEPT</b> use of bioinformatics to show that the base sequences were similar</p> | (2)  |

Q5.

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>The only correct answer is C.</p> <p><i>A is incorrect because dendrochronology is dating trees using tree rings</i><br/> <i>B is incorrect because epigenetics studies changes in gene expression</i><br/> <i>D is incorrect because species diversity is a measure of the number of different species in an area</i></p> | (1)  |

| Question number | Answer                                                                                     | Additional guidance                                                                                                              | Mark |
|-----------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>0.12 (1)</li> <li>mm hr<sup>-1</sup> (1)</li> </ul> | <p><b>NB</b> If different units have been used, award a correct numerical value<br/> e.g. 0.012 cm hr<sup>-1</sup> = 2 marks</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                                                                                            | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An answer that includes three of the following points:</p> <ul style="list-style-type: none"> <li>suitable as a mean is calculated (1)</li> <li>but there is no indication of sample size so may not be that suitable(1)</li> <li>data looks more suitable in the first 45 hours as the error bars are small (1)</li> <li>may not be suitable as the incubation temperature may be different to body temperature (1)</li> <li>will not be suitable if person died more than 120 hours ago (1)</li> </ul> | <p><b>ACCEPT</b> {reliable / accurate} as an alternative for suitable throughout</p> <p><b>ACCEPT</b> overall the error bars are (quite) small</p> <p><b>parts</b> of the graph where the error bars do not overlap are suitable / converse</p> <p><b>ACCEPT</b> body temperature does not remain constant</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>A description that includes three of the following points:</p> <ul style="list-style-type: none"> <li>(start the investigation with) several blowfly eggs (1)</li> <li>measure the length of larvae (at intervals) over a period of 120 hours (1)</li> <li>credit a named control variable appropriate to this data collection (1)</li> <li>calculate mean <b>and</b> {standard deviation / range bars / error bars} (1)</li> </ul> | <p>e.g. same food supply, species of blowfly</p> <p><b>IGNORE</b> inappropriate named control variables eg pH</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                            | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An answer that includes four of the following points:</p> <p><b>THREE FROM:</b></p> <ul style="list-style-type: none"> <li>body temperature is readily available information</li> <li>{calibration curves / formulae} available to work backwards to estimate time of death (1)</li> <li>but the change in body temperature is due to several factors (1)</li> <li>credit example of one of these factors (1)</li> </ul> <p><b>AND</b></p> <ul style="list-style-type: none"> <li>therefore of limited use unless used in conjunction with other methods (1)</li> </ul> | <p><b>ACCEPT</b> calculations can be made to estimate time of death</p> <p><b>e.g.</b> ambient temperature</p> <p><b>ACCEPT</b> on its own</p> | (4)  |

Q6.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark                          |                               |                            |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------------------------|----------------------------|--|--|-------------------------|-------------------------------|-------------------------------|----------------------------|---------|--------------------------|----------|--------------------------|--------------------------|---------|----------|--------------------------|--------------------------|--------------------------|----------|--------------------------|--------------------------|----------|--------------------------|--------|--------------------------|----------|--------------------------|--------------------------|--|
| (a)             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                               |                               |                            |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
|                 | <table><tr><th rowspan="2">Structure</th><th colspan="4">Carbohydrate found in</th></tr><tr><th>both plants and animals</th><th>plants but <b>not</b> animals</th><th>animals but <b>not</b> plants</th><th>neither plants nor animals</th></tr><tr><td>Amylose</td><td><input type="checkbox"/></td><td><b>X</b></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr><tr><td>Glucose</td><td><b>X</b></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr><tr><td>Glycogen</td><td><input type="checkbox"/></td><td><input type="checkbox"/></td><td><b>X</b></td><td><input type="checkbox"/></td></tr><tr><td>Starch</td><td><input type="checkbox"/></td><td><b>X</b></td><td><input type="checkbox"/></td><td><input type="checkbox"/></td></tr></table> | Structure                     | Carbohydrate found in         |                            |  |  | both plants and animals | plants but <b>not</b> animals | animals but <b>not</b> plants | neither plants nor animals | Amylose | <input type="checkbox"/> | <b>X</b> | <input type="checkbox"/> | <input type="checkbox"/> | Glucose | <b>X</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | Glycogen | <input type="checkbox"/> | <input type="checkbox"/> | <b>X</b> | <input type="checkbox"/> | Starch | <input type="checkbox"/> | <b>X</b> | <input type="checkbox"/> | <input type="checkbox"/> |  |
| Structure       | Carbohydrate found in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                               |                               |                            |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
|                 | both plants and animals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | plants but <b>not</b> animals | animals but <b>not</b> plants | neither plants nor animals |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
| Amylose         | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>X</b>                      | <input type="checkbox"/>      | <input type="checkbox"/>   |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
| Glucose         | <b>X</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <input type="checkbox"/>      | <input type="checkbox"/>      | <input type="checkbox"/>   |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
| Glycogen        | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <input type="checkbox"/>      | <b>X</b>                      | <input type="checkbox"/>   |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |
| Starch          | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>X</b>                      | <input type="checkbox"/>      | <input type="checkbox"/>   |  |  |                         |                               |                               |                            |         |                          |          |                          |                          |         |          |                          |                          |                          |          |                          |                          |          |                          |        |                          |          |                          |                          |  |

(4)

| Question number | Answer                                                                                                    | Additional guidance                                                         | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>diffusion of carbon dioxide / carbon dioxide dissolving</li> </ul> | <p><b>ACCEPT</b> CO<sub>2</sub></p> <p><b>DO NOT ACCEPT</b> CO / Co / C</p> | (1)  |

| Question number | Answer                                                                                                      | Additional guidance                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------|
| (b)(ii)         | <ul style="list-style-type: none"> <li><math>6.1 \times 10^{13}</math> / 61 000 000 000 000 (kg)</li> </ul> | <p><b>ACCEPT</b> 61 trillion / 61 millionmillion</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                     | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|------|
| (b)(iii)        | <p>A description that includes three of the following points:</p> <ul style="list-style-type: none"> <li>as carbon dioxide from respiration (1)</li> </ul> <p><b>AND ANY TWO FROM:</b></p> <ul style="list-style-type: none"> <li>by plants (1)</li> <li>by microorganisms that decompose (dead) plants (1)</li> <li>by {animals that eat the plants / herbivores} (1)</li> </ul> | <p><b>DO NOT ACCEPT</b> CO / Co / C</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>(anthropogenic) caused by the effect of humans (1)</li> <li>(climate change) changes to (mean) {temperature / rainfall} (1)</li> </ul> | <p><b>IGNORE</b> named activities</p> <p><b>ACCEPT</b> long-term (mean) change in weather patterns</p> <p><b>IGNORE</b> weather unqualified / global warming / results of global warming / climate</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional guidance                                                                                                          | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>named example of method to reduce the burning of fossil fuels</li> <li>because this will reduce the carbon dioxide released into the atmosphere (1)</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>reforestation (1)</li> <li>because more plants will absorb more carbon dioxide for photosynthesis (1)</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>reduce the number of cattle being farmed (1)</li> <li>as this will reduce the methane being released into the atmosphere (1)</li> </ul> | <p><b>e.g.</b> lift sharing, public transport, use of solar power</p> <p><b>ACCEPT</b> reduce the extent of rice farming</p> | (2)  |

Q7.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>The only correct answer is <b>D</b> blood type O</p> <p><b>A</b> is incorrect because A antigens are not present on red blood cells of humans with blood group B or O</p> <p><b>B</b> is incorrect because B antigens are not present on red blood cells of humans with blood group A or O</p> <p><b>C</b> is incorrect because A antigens are not present on red blood cells of humans with blood group B or O and B antigens are not present on red blood cells of humans with blood group A or O</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                           | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>B antigens are recognised as foreign antigens (1)</li> <li>and therefore initiate an (humoral) immune response (1)</li> <li>credit details of humoral immune response (1)</li> <li>resulting in antibodies released by plasma cells (1)</li> <li>credit consequence of humoral immune response (1)</li> </ul> | <p>e.g. opsonisation / agglutination / destruction of RBCs (in liver / spleen / by phagocytes / formation of memory cells</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                          | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>they {reduce / destroy / prevent the growth of / prevent the infection of} pathogenic bacteria (1)</li> <li>because they compete for {nutrients / named nutrient / space} (1)</li> <li>produce {toxins / chemicals} (that destroy pathogenic bacteria) (1)</li> </ul> | <p><b>ACCEPT</b> {foreign / other} bacteria / pathogens</p> <p><b>IGNORE</b> food</p> <p><b>ACCEPT</b> produce vitamin K</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                    | Additional guidance                                                                                 | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>(because the bacteria can) {absorb / use} sugar for respiration (1)</li> <li>to produce ATP (for the bacteria) (1)</li> </ul> | <p><b>ACCEPT</b> glucose for sugar throughout</p> <p><b>ACCEPT</b> {it / they} to mean bacteria</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>there will be no (foreign) antigens on the red blood cells (1)</li> <li>the immune response will not be triggered (1)</li> <li>therefore this blood can be used in any transfusion (if no antigens present) (1)</li> </ul> | <p><b>ACCEPT</b> antigens removed from the red blood cells<br/>red blood cells will not be recognised as {foreign / non-self}</p> <p><b>ACCEPT</b> can be used in a transfusion as will not be rejected<br/>blood will act like {group O blood / universal donor}</p> | (2)  |

Q8.

| Question number | Answer                                  |                                    |             |              |                            | Mark |
|-----------------|-----------------------------------------|------------------------------------|-------------|--------------|----------------------------|------|
| (a)             | <b>Statement</b>                        | <b>Type of artificial immunity</b> |             |              |                            | (3)  |
|                 |                                         | both active and passive            | active only | passive only | neither active nor passive |      |
|                 | Antibodies are injected into the person |                                    |             | X            |                            |      |
|                 | B cells differentiate into plasmacells  |                                    | X           |              |                            |      |
|                 | Memory cells are formed                 |                                    | X           |              |                            |      |

| Question number | Answer                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                                                                                                                            | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>engulf the virus / phagocytosis of the virus (1)</li> <li>digestion of the virus (1)</li> <li>antigen presentation to {T helper / CD4} {cells / lymphocytes}(1)</li> </ul> | <p><b>ACCEPT</b> pathogen, if in context of virus<br/>reference to a macrophage being a phagocyte, if in context of viruses</p> <p><b>DO NOT ACCEPT</b> kills the virus</p> <p><b>ACCEPT</b> macrophage is an {antigen presenting cell / APC} to T helper cells<br/><b>DO NOT ACCEPT</b> to T killer cells</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                                                               | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>T helper cells {activate / stimulate} B cells (to divide) (1)</li> <li>because antibody will be needed for opsonisation</li> <li>T helper cells {activate / stimulate} T killer cells (to divide)(1)</li> <li>because T killer cells destroy (virus-infected) cells (1)</li> <li>so that virus can be {engulfed / destroyed} by macrophages (1)</li> </ul> | <p><b>ACCEPT</b> stimulate humoral response</p> <p><b>ACCEPT</b> antibodies prevent viruses binding to host cells</p> <p><b>ACCEPT</b> stimulate cell-mediated response</p> <p><b>ACCEPT</b> a description</p> <p><b>DO NOT ACCEPT</b> killed pathogen in context of bacteria</p> | (4)  |

Q9.

| Question number | Answer                                                                                             | Additional guidance                                                                                                                         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>methods used to prevent contamination (of person / culture) (with other microorganisms) (1)</p> | <p><b>ACCEPT</b> techniques / procedures / routines</p> <p><b>ACCEPT</b> prevent {entry / exit / infection}</p> <p><b>IGNORE</b> growth</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                                      | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>A description that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• carry out work beside {a bunsen burner / in a hood} (1)</li> <li>• use sterilised {equipment / media} / sterilise equipment after use(1)</li> <li>• credit named personal procedure (1)</li> <li>• minimise the time that cultures are exposed to the air / do not open cultures at the end (1)</li> </ul> | <p><b>ACCEPT</b> description of how equipment could be sterilised e.g. media autoclaved, wash area with disinfectant</p> <p>e.g. wearing gloves, washing hands</p> <p>e.g. transfer bacteria quickly</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------|
| (a)(iii)        | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• to prevent entry of bacteria that may compete with the <i>E. coli</i> (1)</li> <li>• to prevent entry of bacteria that may grow in different {types / concentrations} of microbial substances (than <i>E. coli</i>) (1)</li> <li>• to prevent infection (of person) with bacteria in the culture that {is / maybe} pathogenic (1)</li> </ul> | <p><b>ACCEPT</b> will not know if <i>E. coli</i> or the other bacteria is growing</p> | (2)  |

| Question number | Answer                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• explanation for temperature given (1)</li> <li>• explanation for time given (1)</li> </ul> | <p>e.g. appropriate temperature needed for the enzymes to function temperature not too high so the enzymes do not denature</p> <p><b>ACCEPT</b> proteins for enzymes temp won't be rate limiting for growth</p> <p>e.g. antimicrobial effect can be seen when bacteria are growing enough time has to be allowed for the bacterial growth to become visible enough time for antimicrobials to have an effect</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                          | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------|
| (c)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>to show if the cultures were contaminated (1)</li> <li>because the antimicrobial agent would not {kill / inhibit the growth of} other types of bacteria (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>to check that the <i>E. coli</i> has not changed its {susceptibility / resistance} (1)</li> <li>so that the results will apply to known <i>E. coli</i> (1)</li> </ul> | <p><b>ACCEPT</b> a description e.g. to see if other bacteria are growing</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>to show that the <i>E. coli</i> were viable (1)</li> <li>because if there was not any growth of bacteria you would not know if the bacteria were dead or the antimicrobial agents were (very) effective (1)</li> </ul> | <p><b>ACCEPT</b> alive / can replicate / can grow<br/> <b>ACCEPT</b> to show that the antimicrobials were inhibiting growth<br/> <b>IGNORE</b> antimicrobials affecting growth</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                               | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(iii)        | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>description of adding equal volumes of {antimicrobial substance / antimicrobials / substance / solution} and {water / media / broth / buffer} together (1)</li> <li>description of this being repeated (a few times) using previous solution (1)</li> </ul> | <p><b>ACCEPT</b> the idea of doing this process in the wells directly or separately</p> <p><b>ACCEPT</b> stated volumes / 50% volumes / volumes in ratio 1 : 1<br/> <b>IGNORE</b> amount</p> <p><b>ACCEPT</b> a reference to serial dilutions</p> | (2)  |

| Question number | Answer                                                                                                            | Additional guidance                                                                                                                                                                                                                                             | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(iv)         | <ul style="list-style-type: none"> <li>MIC of E and G calculated (1)</li> <li>{32 / 2<sup>5</sup>} (1)</li> </ul> | <p>MIC of E = 1 in 8 and MIC of G = 1 in 256<br/> Or<br/> MIC of E = 1 in 16 and MIC of G = 1 in 512</p> <p><b>ACCEPT</b> E is {32 / 2<sup>5</sup>} times less effective</p> <p><b>NB</b> correct answer gains 2 marks</p> <p><b>ACCEPT</b> 2.25 for 1 mark</p> | (2)  |

Q10.

| Question number | Answer                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>The only correct answer is A.</p> <p><i>B is incorrect because this is not a method of counting bacteria</i><br/> <i>C is incorrect because colonies are counted not weighed</i><br/> <i>D is incorrect because colonies are counted on agar. Turbidity would not work on agar.</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                    | Additional guidance                                                                                                                                                                                                                                                                                                                                       | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>attach lid to dish to ensure {lid does not fall off / bacteria do not enter / bacteria do not leave / no contamination} (1)</li> <li>not completely sealed {so that conditions remain aerobic / prevent the growth of anaerobic bacteria} (1)</li> </ul> | <p><b>ACCEPT</b> a description for both marking points e.g. sellotape used in places / sellotape not used all the way round</p> <p><b>ACCEPT</b> a description of how to attach e.g. tape up the petri dish, use sellotape to seal petri dish</p> <p><b>ACCEPT</b> leave gaps so there is oxygen</p> <p>NB leave air holes in the sealing = this mark</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>The only correct answer is C.</p> <p><i>A is incorrect because lag comes before exponential and death comes at the end</i><br/> <i>B is incorrect because exponential comes between lag and death</i><br/> <i>D is incorrect because lag comes before exponential and stationery comes after</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>The only correct answer is D.</p> <p><i>A is incorrect because all four are correct</i><br/> <i>B is incorrect because all four are correct</i><br/> <i>C is incorrect because all four are correct</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                  | Additional guidance                                                                                                                                                               | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(iii)        | <ul style="list-style-type: none"> <li><math>\log_{10} N_t</math> and <math>\log_{10} N_0</math> values read from graph and subtracted (1)</li> <li>2.49 (1)</li> </ul> | <p>6.5 - 2 / 4.5<br/> <b>IGNORE</b> 'log' before the 6.5 and 2 if they clearly haven't used the log value</p> <p>ecf if log of logs have been taken and given to 2 dps = 0.28</p> | (2)  |

Q11.

|     | Answer                                                                                                                                                                                                                                                                                                                                                                        | Mark |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a) | <p>The only correct answer is A <math>\log_{10}</math> number of living bacterial cells</p> <p><b>B is incorrect because the total cell number plotted would not show the death phase</b></p> <p><b>C is incorrect because the exponential phase would not be a straight line</b></p> <p><b>D is incorrect because the exponential phase would not be a straight line</b></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                              | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because we do not want {other bacteria in the culture / contamination} (1)</li> <li>as they could {compete for nutrients / produce toxins (to the bacteria being cultured)}</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>because we do not want to transfer the bacteria onto {ourselves / surroundings}</li> <li>as they may be {pathogenic / harmful} (1)</li> </ul> | <p><b>ACCEPT</b> microorganisms / pathogens</p> <p><b>ACCEPT</b> microorganisms competition for space</p> <p><b>ACCEPT</b> prevent infection</p> | (2)  |

| Question number | Answer                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>one named technique explained (1)</li> <li>a second named technique explained (1)</li> </ul> | <p>e.g.<br/>working by a Bunsen burner<br/>+<br/>to create an updraft / to move the microorganisms in the air away / to prevent {bacteria / microorganisms / spores} falling into culture<br/><b>IGNORE</b> kill bacteria in the air</p> <p>autoclaving {agar / culture fluid / equipment} using sterile equipment disinfecting work area washing hands<br/>+<br/>to kill any {bacteria / microorganisms / spores} present</p> <p>washing hands<br/>flaming necks of bottles<br/>+ to prevent transferring {bacteria / microorganisms / spores} into cultures</p> <p>reducing exposure of cultures to air<br/>+<br/>to reduce chance of contamination</p> <p>close {doors / windows}<br/>+<br/>to avoid draughts</p> | (2)  |

Q12.

| Question number | Answer                                                                                                                                              | Additional guidance                                                                                                                                                                               | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <ul style="list-style-type: none"> <li>a {chemical / substance / medicine / drug / compound / molecule} that {kills / destroys} bacteria</li> </ul> | <p><b>ACCEPT</b> pathogen / microorganisms <b>DO NOT ACCEPT</b> viruses<br/>antibodies / antigens</p> <p><b>DO NOT ACCEPT</b> inhibit the growth<br/><b>IGNORE</b> descriptions of mechanisms</p> | (1)  |

| Question number | Answer                                                                                                   | Additional guidance                                                                                                                                      | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <ul style="list-style-type: none"> <li>• bacteria are prokaryotic (and humans are eukaryotic)</li> </ul> | <b>ACCEPT</b> named target site<br>e.g. cell wall, biochemistry, metabolism<br>only prokaryotic cells<br><b>IGNORE</b> specific<br>antigens<br>receptors | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                                                                                                                                                                         | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | A description that includes two of the following points: <ul style="list-style-type: none"> <li>• finish the course of antibiotics (1)</li> <li>• take the antibiotics as directed (by the doctor)</li> <li>• warnings / precautions that may be necessary</li> </ul> | <b>IGNORE</b> advise that would be given to doctors and not the patients<br><br><b>ACCEPT</b> specific examples<br>e.g.<br>correct {dose / number / timings}, do not share your antibiotics, do not take antibiotics not prescribed (by your doctor)<br><br>e.g. they might make you sleepy | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                            | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (d)             | A description that includes the following points: <ul style="list-style-type: none"> <li>• bacteria types J and K are {destroyed / killed / eradicates} (1)</li> <li>• antibiotic results in an increase in {proportion / percentage / ratio} of bacteria types M and N (1)</li> <li>• bacteria type O and L {not affected / growth inhibited} (1)</li> </ul> | Piece together<br><br><b>ACCEPT</b> antibiotic is bactericidal to J and K<br><br><b>IGNORE</b> increase in number<br><br><b>ACCEPT</b> antibiotic is bacteriostatic to O and L | (3)  |

| Question number | Answer    | Additional guidance | Mark |
|-----------------|-----------|---------------------|------|
| (a)(i)          | 7 (g) (1) |                     | (1)  |

| Question number | Answer                                                                                                                                                                       | Additional guidance                                                                                                                                  | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <ul style="list-style-type: none"> <li>value given in the range 0.005 to 0.0083 (1)</li> <li>this value given to 1 or 2 sig figs {per day / day<sup>-1</sup>} (1)</li> </ul> | <p><b>ACCEPT</b> answers in correct standard form to 1 or 2 sig figs</p> <p><b>ACCEPT</b> {0.02 / 0.017} {per day / day<sup>-1</sup>} for 1 mark</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                         | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iii)        | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>decomposition (of tea) is {faster / greater} at 25°C (1)</li> <li>because enzymes {work faster / move faster / have more kinetic energy} (at warmer temperatures) (1)</li> <li>as there are more (frequent / energetic) enzyme-substrate collisions (1)</li> <li>loss of mass is due to release of carbon dioxide (1)</li> <li>by the respiration of the {decomposers / bacteria / fungi} (1)</li> </ul> | <p><b>ACCEPT</b> converse throughout</p> <p><b>ACCEPT</b> description e.g. breakdown of organic matter</p> <p><b>ACCEPT</b> may be due to more bacteria</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                    | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iv)         | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>because the teas maybe composed of different molecules (1)</li> <li>that {cannot be broken down as easily / are less accessible to theenzymes} (in rooibos) (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>because the pH (in the teabag) is different (1)</li> <li>therefore enzymes (of the bacteria) are less active (in rooibos) (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>because there are {inhibitors / antimicrobials / toxins} in rooibos(1)</li> <li>that {inhibit the enzymes / kill the decomposers} (1)</li> </ul> | <p><b>ACCEPT</b> converse throughout</p> <p><b>ACCEPT</b> named difference e.g. surface area</p> <p><b>IGNORE</b> different masses of organicmatter</p> <p><b>ACCEPT</b> which enzymes cannot breakdown</p> <p><b>ACCEPT</b> higher concentrations</p> | (2)  |

| Question number | Answer                                                                                                                                           | Additional guidance            | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>both the decomposition rate and {S / stabilisation factor / carbon stored} are mean values (1)</li> </ul> | <b>ACCEPT</b> average for mean | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                                                       | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes three of the following points:</p> <ul style="list-style-type: none"> <li>{number 6 / loamy desert} (and 3 / birch / 5 / sandy desert) (1)</li> <li>because it has the highest S value and the lowest decompositionrate (1)</li> <li>therefore more carbon retained (in the soil) and less {carbon / carbon dioxide} released (1)</li> <li>less carbon dioxide (in the atmosphere), the less global warming (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>{number 6 / loamy desert} (and 3 / birch / 5 / sandy desert) (1)</li> <li>because it has the highest S value therefore more carbon retained(in the soil) (1)</li> <li>because it has the lowest decomposition rate and therefore less {carbon / carbon dioxide} released (1)</li> <li>less carbon dioxide (in the atmosphere), the less global warming (1)</li> </ul> | <p><b>DO NOT ACCEPT</b> carbon dioxide retained</p> <p><b>ACCEPT</b> less greenhouse effect, description</p> <p><b>DO NOT ACCEPT</b> carbon dioxide retained</p> <p><b>ACCEPT</b> less greenhouse effect, description</p> | (3)  |

Q14.

| Question number | Answer                                                                                                                                        | Additional guidance                                                                                 | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------|
| (a)             | <ul style="list-style-type: none"> <li>using a {thermometer / (temperature) probe} to take the temperature of the {liver / rectum}</li> </ul> | <b>ACCEPT</b> into the core / deep into the body / up the anus<br><b>IGNORE</b> other parts of body | (1)  |

| Question number | Answer                                                                                                                                                                                                                              | Additional guidance                                                                                                                    | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>drop in body temperature in first 12 hours calculated and subtracted from 11.5°C (1)</li> <li>this value divided by 0.4, added to 12 hours and answer rounded to nearest hour (1)</li> </ul> | $11.5 - (0.78 \times 12) / 11.5 - 9.36 / 2.14$<br><br>17 (hours)<br>17.35 = 1 mark<br><br>Correct answer with no working gains 2 marks | (2)  |

| Question number | Answer                                                                                                                                                                                                                                      | Additional guidance    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|
| (b)(ii)         | An explanation that includes the following points: <ul style="list-style-type: none"> <li>(this) estimate would be {shorter / an under-estimate} (1)</li> <li>because a body loses <u>heat</u> faster (in cooler conditions) (1)</li> </ul> | <b>ACCEPT</b> converse | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | An explanation that includes three of the following points: <ul style="list-style-type: none"> <li>because temperature affects {rigor / body stiffness} (1)</li> <li>because deciding when a body is stiff or not stiff is subjective (1)</li> <li>because if the body is stiff, the time since death can only be estimated as being between 3 and 36 hours (1)</li> <li>because if the body is not stiff, there is no way of telling if it has been dead for less than 3 hours or more than 36 hours (1)</li> </ul> | <b>ACCEPT</b> exercise / body shape / body fat / ATP levels<br><br><b>ACCEPT</b> gives a wide range of (time) values<br><br><b>ACCEPT</b> if not stiff cannot tell how many hours after 36 hours time of death was | (3)  |

Q15.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                                                                              | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>A description that includes three of the following points:</p> <ul style="list-style-type: none"> <li>• whether it caused side effects (in humans) (1)</li> <li>• whether or not it reduced the size of the plaques (1)</li> <li>• {(an effective) concentration / the half life} of the drug (1)</li> <li>• the (best) method to administer the drug (1)</li> <li>• how long to administer drug (for amyloid to be destroyed) (1)</li> </ul> | <p><b>ACCEPT</b> named side effect<br/>e.g. allergic reaction</p> <p><b>ACCEPT</b> {plaque / amyloid}<br/>disappeared better<br/>than existing drugs<br/>effective</p> <p><b>ACCEPT</b> dose</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                           | Additional guidance                                | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• antibodies can <u>only</u> bind to their antigen / this antibody can <u>only</u> bind to B amyloid (1)</li> <li>• because of the (complementary) shape of {antigen / antibody} (1)</li> </ul> | <b>ACCEPT</b> FAB region / FAB receptor / receptor | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>• {ATD / antibodies} will bind to the <u>amyloid</u> (1)</li> <li>• macrophages engulf the amyloid (1)</li> <li>• macrophages {destroy / digest} the amyloid with {enzymes / lysozymes} (1)</li> </ul> | <p><b>ACCEPT</b> opsonisation</p> <p><b>ACCEPT</b> phagocytes / neutrophils</p> <p><b>ACCEPT</b> phagocytes / neutrophils protease</p> <p><b>DO NOT ACCEPT</b> lysosome</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                                                                                            | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>because their immune system had already been activated (against amyloid) (1)</li> <li>and therefore {the amyloid was broken down / plaques could not form} (by phagocytes) (1)</li> </ul> | <p><b>ACCEPT</b> a description e.g. a primary immune response had already taken place, the person had memory cells (to amyloid)<br/>antibodies present</p> <p><b>DO NOT ACCEPT</b> by antibodies / B cells</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because people with Alzheimer's disease will not have these memory cells (1)</li> <li>and therefore there will not be any memory cells that can differentiate into the plasma cells that produce the antibody (1)</li> </ul> | <p><b>ACCEPT</b> B memory cells not effective</p> <p><b>ACCEPT</b> no memory cells that will result in the production of antibody <b>DO NOT ACCEPT</b> no memory cells to produce the antibody</p> | (2)  |

Q16.

| Question number | Answer                                                              | Mark |
|-----------------|---------------------------------------------------------------------|------|
| (a)(i)          | B human immunodeficiency virus (HIV) and tobacco mosaic virus (TMV) | (1)  |

| Question number | Answer                            | Mark |
|-----------------|-----------------------------------|------|
| (a)(ii)         | D tobacco mosaic virus (TMV) only | (1)  |

| Question number | Answer    | Mark |
|-----------------|-----------|------|
| (a)(iii)        | D protein | (1)  |

| Question number | Answer                                                                                                                                                                                                                                         | Additional guidance                                                | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------|
| (a)(iv)         | <ul style="list-style-type: none"> <li>• calculation of volume of TMV (1)</li> <li>• calculation of size difference (1)</li> </ul> <p>Example of calculation:</p> $3.14 \times 40 \times 40 \times 300 = 1\,507\,200$ <p>19 / 19.4 / 19.42</p> | Allow ecf<br>Correct answer with no working shown gains full marks | (2)  |

| Question number | Answer                                | Mark |
|-----------------|---------------------------------------|------|
| (b)(i)          | • reverse transcriptase and integrase | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• because these enzymes are not present in the host cell (1)</li> <li>• because reverse transcriptase is needed to make a DNA copy of the viral RNA (1)</li> <li>• because integrase is needed to incorporate the DNA copy into the host cell genome (1)</li> </ul> | (3)  |

Q17.

| Question number | Answer                                                                                                  | Additional guidance                                        | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------|
| (a)(i)          | <ul style="list-style-type: none"> <li>• not enough (male) birds left to teach them the song</li> </ul> | <b>ACCEPT</b> hear the songs of other birds and learn them | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>female birds will not recognise the males (song / courtship behaviour) (1)</li> <li>therefore the level of breeding may drop (1)</li> <li>therefore the number of birds will drop (further) / extinction (1)</li> <li>hybridisation may occur (1)</li> </ul> | <p><b>ACCEPT</b> reduced mating / reproduction</p> <p><b>ACCEPT</b> mating with another <u>species</u> would produce infertile offspring</p> <p><b>IGNORE</b> references to reproductive isolation</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                    | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------|
| (a)(iii)        | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>keep them away from other species / house them with (only) their species (1)</li> <li>(in captivity) keep with other birds that can sing the songs (to teach them) (1)</li> <li>and then release the birds that have learnt the song back into the wild (1)</li> </ul> | <p><b>ACCEPT</b> play recorded {songs / videos} / whistle the song</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                    | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>take DNA samples from {feather / dropping / skin / blood} (of both species) (1)</li> <li>use of PCR (1)</li> <li>(followed by) (gel) electrophoresis (1)</li> <li>{number / width / position / patterns} of <u>bands</u> will show similarities (1)</li> </ul> | <p><b>ACCEPT</b> DNA profiling / bioinformatics</p> <p><b>ACCEPT</b> similar base sequences (using DNA profiling / bioinformatics)</p> | (4)  |

Q18.

|        | Answer                                                                                                                                                                                                                                 | Mark |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i) | <p>The only correct answer is <b>C</b>.</p> <p><i>A is incorrect because m is an area so two dimensional</i><br/> <i>B is incorrect because year is one dimensional</i><br/> <i>D is incorrect because year is one dimensional</i></p> | (1)  |

|         | Answer                                                                                                                                                                                                                                  | Mark |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii) | <p>The only correct answer is <b>B</b>.</p> <p><i>A is incorrect because <math>NPP = GPP - R</math></i><br/> <i>C is incorrect because <math>NPP = GPP - R</math></i><br/> <i>D is incorrect because <math>NPP = GPP - R</math></i></p> | (1)  |

| Question number | Answer                                                          | Additional guidance                                                                                                                                                 | Mark |
|-----------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iii)        | <ul style="list-style-type: none"> <li>• 98 : 10 : 1</li> </ul> | <p><b>ACCEPT</b> 98 : 9.6 : 1<br/>           98.3 : 9.6 : 1<br/>           100 : 10 : 1</p> <p>10 : 1 : 0.1<br/>           10.3 : 1 : 0.1</p> <p>1 : 0.1 : 0.01</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                            | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------|
| (a)(iv)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• because not enough energy (in trophic level 3) (1)</li> <li>• to sustain (organisms in) a fourth trophic level (1)</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>• energy is lost between trophic levels (1)</li> <li>• so not enough energy for another trophic level (1)</li> </ul> | <p><b>IGNORE</b> no energy / biomass</p> <p><b>ACCEPT</b> support</p> <p><b>IGNORE</b> no energy / biomass</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                            | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(v)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>breakdown organic matter (1)</li> <li>with (hydrolytic) enzymes (1)</li> <li>releasing carbon <u>dioxide</u> from respiration (to the atmosphere) (1)</li> <li>where it is used for photosynthesis (by plants) (1)</li> </ul> | <p><b>ACCEPT</b> dead {tree / gerenuk / lion} / tissues / named organic molecule</p> <p><b>ACCEPT</b> named enzyme</p> <p><b>NB</b> release {digestive / hydrolytic} enzymes onto dead organisms = 2 marks</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                        | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| *(b)            | <p><b>Level 1 points:</b></p> <ul style="list-style-type: none"> <li>due to natural selection</li> </ul> <p>(Descriptions of differences in features)</p> <ul style="list-style-type: none"> <li>gerenuk's food is higher up / springbok's food is lower down</li> <li>gerenuks have longer {necks / limbs}</li> <li>gerenuk's white areas are {underneath / more concealed}</li> <li>better adapted organisms survive and reproduce</li> <li>passing their alleles onto their offspring</li> </ul> <p><b>Level 2 points:</b></p> <ul style="list-style-type: none"> <li>occupy a different niche because they eat different food</li> </ul> <p>(Descriptions of how mutation caused a difference)</p> <ul style="list-style-type: none"> <li>change in length of {neck / limbs} due to a mutation</li> <li>change in type of horns due to a mutation</li> </ul> <p>(Explanations of how a features are an adaptation / result in difference in behaviour)</p> <ul style="list-style-type: none"> <li>organisms with longer neck could reach the higher leaves</li> <li>organisms with smaller horns did not get caught up in branches</li> <li>smaller organisms had to go to waterhole for water</li> <li>organisms with larger horns could defend off predators</li> <li>male gerenuks kept horns for fighting for females</li> </ul> <p>reference to {reduced gene flow / change in allele frequency /</p> | <p><b>Level 1:</b></p> <p>1 mark = 1 point made from any level</p> <p>2 marks = 3 points made from any level</p> <p><b>Level 2:</b></p> <p><b>NB Must be a reference to the data / context of the question</b></p> <p>3 marks = 4 points made which include at least one level 2 point</p> |      |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                                                                                                                                 | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|                 | <p>reproductive isolation} with no links made</p> <p><b>Level 3 points:</b></p> <ul style="list-style-type: none"> <li>length of {neck / limbs} is a polygenic characteristic</li> <li>type of horns is a polygenic characteristic</li> <li>therefore organisms will show (continuous) variation for this phenotype</li> <li>height of food acted as a selection pressure on size</li> <li>{branches / predators} acted as a selection pressure on horns</li> <li>organisms that {occupy a different niche / feed on different food} are not in competition with each other</li> <li>two groups of organisms moved apart depending on where their food was</li> <li>sympatric speciation / organisms not separated by a physical barrier</li> <li>therefore reduced gene flow (between the two groups)</li> <li>resulting in changes in the allele frequency</li> <li>eventually resulting in reproductively isolated</li> <li>and the formation of two species</li> </ul> | <p>4 marks =<br/>5 points made which include at least one level 2 point</p> <p><b>Level 3:</b><br/><b>NB Horns and {leg / neck} length must be included</b><br/>5 marks =<br/>6 points made which includes at least one level 3 point<br/>6 marks =<br/>7 points made which includes at least one level 3 point</p> | <b>(6)</b> |

Q19.

| Question number | Answer                                                                                                                                                                                                                   | Additional guidance                                                                                                                                                                   | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| (a)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>explanation of why another method is not accurate (1)</li> <li>explanation of why entomology is accurate (1)</li> </ul> | <p>e.g. drop in body temperature is dependent on ambient temperature</p> <p>e.g. knowing life cycles and timings insects {colonise dead body in specific order / show succession}</p> | <b>(2)</b> |

| Question number | Answer                                                                                                                                                                                                                                                   | Additional guidance | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>some {insects /species} only found in certain habitats (1)</li> <li>therefore if non-native species found on the body, it has been moved (1)</li> </ul> |                     | <b>(2)</b> |

| Question number | Answer                                                                                                                                                  | Additional guidance                                                                                                      | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------|
| (b)(i)          | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>to prevent animals from {eating / moving} it (1)</li> </ul> | <p><b>ACCEPT</b> scavengers / carnivores appropriate named animal<br/>e.g. vulture, wolf<br/><b>IGNORE</b> predators</p> | <b>(1)</b> |

| Question number | Answer                                                                                                                                       | Additional guidance                                                                                                                                                                                            | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <ul style="list-style-type: none"> <li>values read from the graph at 5 and 15 days / a value divided by 240 (1)</li> <li>0.08 (1)</li> </ul> | <p>e.g. of calculation</p> <p>21 to 22 and 3 / in the range of 0.075 to 0.079166</p> <p>Bald answer of 0.08 = 2 marks</p> <p>Bald answer between 0.075 and 0.079167 rounded up to more than 2 dps = 1 mark</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>{very little / no} change at start because {body not colonised by insects / only insect eggs present} (1)</li> <li>{small decrease at /end of bloated stage / 3.5 days} due to wild animals eating flesh (1)</li> <li>{large decrease in mass / at beginning of active stage / 5 days} as holes in flesh allow gases to escape (1)</li> <li>{decrease in mass / during active and advanced stages} as insects eat the flesh (1)</li> <li>some mass remains because bones cannot be {eaten / digested} (1)</li> </ul> | <p><b>ACCEPT</b> very few microorganisms present decomposition has not started</p> <p><b>ACCEPT</b> decomposition by microorganisms small volume of gas released some insects have started to eat loss of water</p> <p><b>ACCEPT</b> mass remains constant because bones remain remains cannot be digested</p> <p><b>NB</b> If no marks are awarded allow 1 mark for a description of decomposition</p> | (4)  |

| Question number | Answer                                                                                                                                                                       | Additional guidance | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(iv)         | <ul style="list-style-type: none"> <li>to identify the <u>species</u> (that laid the eggs) / to determine time until hatching to find out when they were laid (1)</li> </ul> |                     | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|
| (b)(v)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• succession means that the species of insects (found on the decomposing mammal) will {change with time / change with stage (of decomposition) / appear in a specific sequence} (1)</li> <li>• <i>Lucilia</i> appears on the body first (1)</li> <li>• then {<i>Cochliomyia</i> / <i>Chrysomya</i>} appear on the body and <i>Lucilia</i> {numbers decrease / is out competed} (1)</li> <li>• then <i>Ophyra</i> arrives and {<i>Cochliomyia</i> / <i>Chrysomya</i>} {decrease in number / are out competed} (1)</li> </ul> | ACCEPT pioneer species | (3)  |

Q20.

| Question number | Answer                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>The only correct answer is D.</p> <p><i>A is incorrect because R is a glycoprotein</i><br/> <i>B is incorrect because Q is an enzyme</i><br/> <i>C is incorrect because S is the capsid</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>The only correct answer is D.</p> <p><i>A is incorrect because Q is an enzyme, R is a glycoprotein and S is the protein capsid</i><br/> <i>B is incorrect because Q is an enzyme, R is a glycoprotein and S is the protein capsid</i><br/> <i>C is incorrect because Q is an enzyme, R is a glycoprotein and S is the protein capsid</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                               | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iii)        | <p>The only correct answer is A.</p> <p><i>B is incorrect because TMV does not have an envelope</i><br/> <i>C is incorrect because TMV does not have an envelope</i><br/> <i>D is incorrect because Ebola virus has both an envelope and RNA</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                            | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iv)         | <p>The only correct answer is D.</p> <p><i>A is incorrect because 60mm is 60 000 000 nm, divide this by 120nm = 500 000</i><br/> <i>B is incorrect because 60mm is 60 000 000 nm, divide this by 120nm = 500 000</i><br/> <i>C is incorrect because 60mm is 60 000 000 nm, divide this by 120nm = 500 000</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>because the y axis would have to be extended to {37 / 38 / 39 / 40} (1)</li> <li>otherwise this would make the rest of the data too squashed (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>so that <u>all</u> the data can be plotted on one graph (1)</li> <li>so that it can <u>all</u> be compared (1)</li> </ul> | <p><b>ACCEPT</b> would require a bigger scale<br/>larger graph</p> <p><b>ACCEPT</b> changes in deaths and new infections would not be so accurately presented</p> <p><b>ACCEPT</b> with data for new infections and deaths<br/><b>IGNORE</b> easier / harder other data</p> <p><b>ACCEPT</b> with data for new infections and deaths<br/><b>IGNORE</b> easier / harder other data</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                           | Additional guidance         | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|------|
| (b)(ii)         | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>two values read from graph, subtracted and divided by 5 (1)</li> <li><math>2 \times 10^5</math> / <math>2.0 \times 10^5</math> / <math>2.00 \times 10^5</math> (1)</li> </ul> | $(3.2 - 3.1) \div 5 = 0.02$ | (2)  |

| Question number | Answer                                                                                                                                                                                                                                              | Additional guidance                                                                                                                       | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>more infected people are surviving (1)</li> <li>(more) people are surviving due to {better / new} {treatments / health care} (1)</li> </ul> | <p><b>ACCEPT</b> fewer infected people are dying<br/><b>IGNORE</b> death rates</p> <p><b>IGNORE</b> vaccines, antibiotics, technology</p> | (2)  |

| Question number | Answer                                                                                                                        | Additional guidance                                                                                 | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------|
| (b)(iv)         | <ul style="list-style-type: none"> <li>• extrapolation (of data / graph / line) / extending the line (to 2025) (1)</li> </ul> | <b>ACCEPT</b> <u>extend</u> a line of best fit<br><b>IGNORE</b> draw a line of best fit unqualified | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional guidance                                                            | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------|
| (b)(v)          | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• because vaccines result in {(artificial active) immunity / an immune response} (1)</li> <li>• due to the {formation / presence} of memory cells (1)</li> <li>• therefore (as a result of the vaccine) there would be fewer people with HIV (1)</li> <li>• and therefore non-immune people less likely to become infected by someone with HIV (1)</li> </ul> | <b>ACCEPT</b> number of infections decrease<br><br><b>ACCEPT</b> herd immunity | (3)  |

Q1.

The immune response to cancer involves both T helper and T killer cells.

(a) Which row of the table shows the cells that present antigens to each of these T cells?

(1)

|                                       | T helper cells      | T killer cells      |
|---------------------------------------|---------------------|---------------------|
| <input checked="" type="checkbox"/> A | host-infected cells | host-infected cells |
| <input checked="" type="checkbox"/> B | host-infected cells | macrophages         |
| <input checked="" type="checkbox"/> C | macrophages         | host-infected cells |
| <input checked="" type="checkbox"/> D | macrophages         | macrophages         |

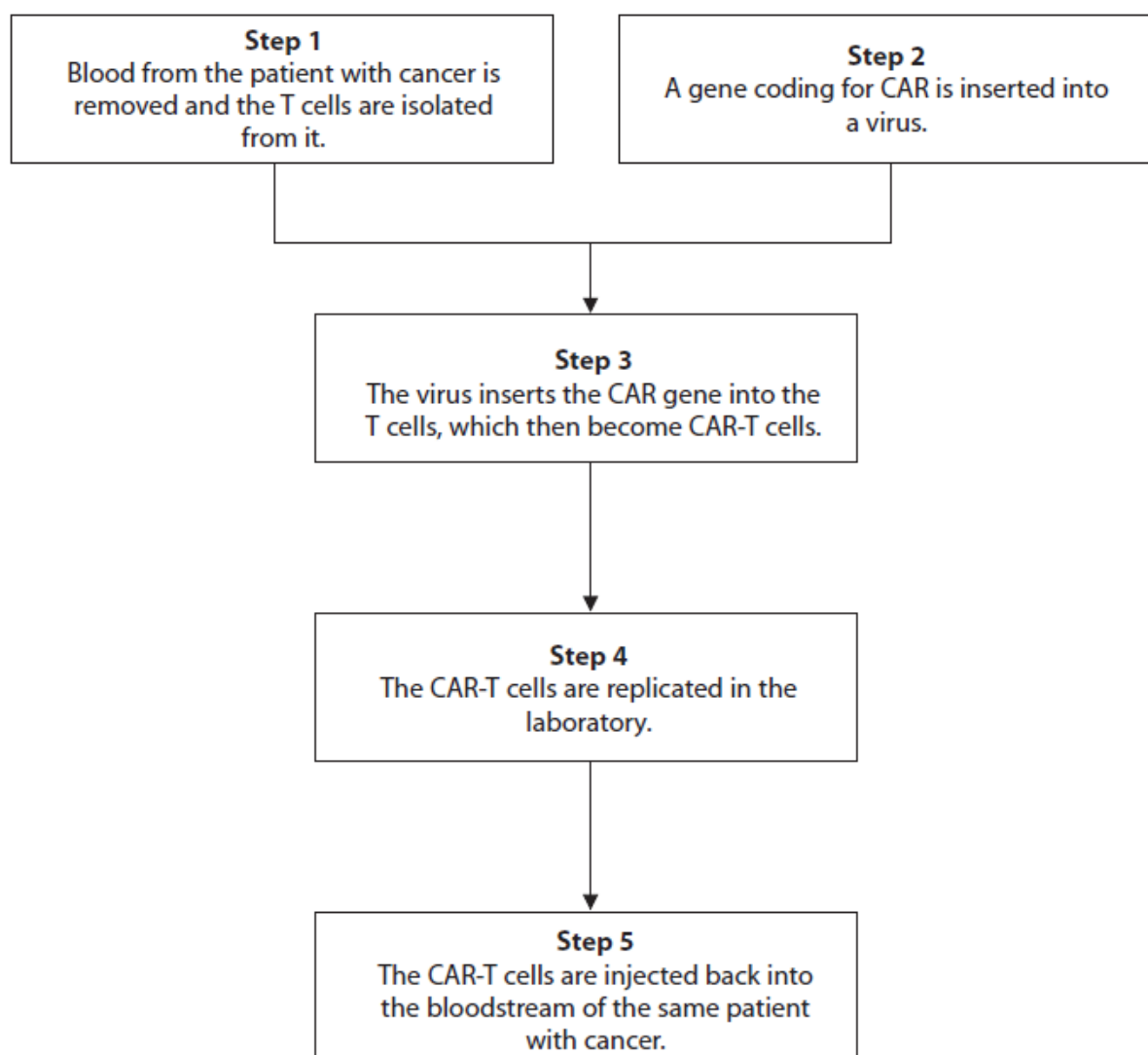
(b) Immunotherapy, using genetically-modified T cells, is being developed to treat blood cell cancers.

Cancer cells have a specific antigen on their surface.

The T cells have to possess a receptor (CAR) on their surface that binds to this antigen.

A gene coding for CAR has to be inserted into the T cells. These genetically-modified T cells are called CAR-T cells.

The diagram shows some steps in this procedure.



(i) The virus used in this procedure is modified so that it is not pathogenic.

Which virus would be suitable to use in **Step 2**?

(1)

- ☐ **A** Ebola virus
- ☐ **B** human immunodeficiency virus (HIV)
- ☐ **C** lambda phage ( $\lambda$  phage)
- ☐ **D** tobacco mosaic virus (TMV)

(ii) Explain why the CAR gene is inserted into the T cells in **Step 3**.

(2)

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(iii) Explain the importance of mitosis in the replication of the CAR-T cells in **Step 4**.

(3)

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(iv) In **Step 1**, T cells are removed from a patient with cancer.

Explain the advantages of injecting CAR-T cells into the same patient in **Step 5**.

(3)

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(v) Currently, the use of CAR-T cells has been effective against blood cell cancers only.

Suggest why CAR-T cells are not effective against cancer cells in solid tumours growing in other tissues in the body.

(2)

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**(Total for question = 12 marks)**

Q2.

Human Immunodeficiency Virus (HIV) infects human cells, causing symptoms that may result in death.

(a) Explain why the virus is an immunodeficiency virus.

(4)

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(b) A number of antiretroviral drugs are given to patients with HIV.  
These include reverse transcriptase inhibitors and integrase inhibitors.

(i) Explain how these two drugs reduce the development of HIV.

(2)

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(ii) These two drugs are often given in combination with other antiretroviral drugs.  
Suggest why patients are given combinations of drugs.

(2)

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(iii) If a patient stops taking the antiretroviral drugs, the number of virus particles increases again.  
Suggest why this increase occurs.

(2)

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Q3.

Antibodies play an important role in the immune response.

(a) Explain the importance of antibodies.

(4)

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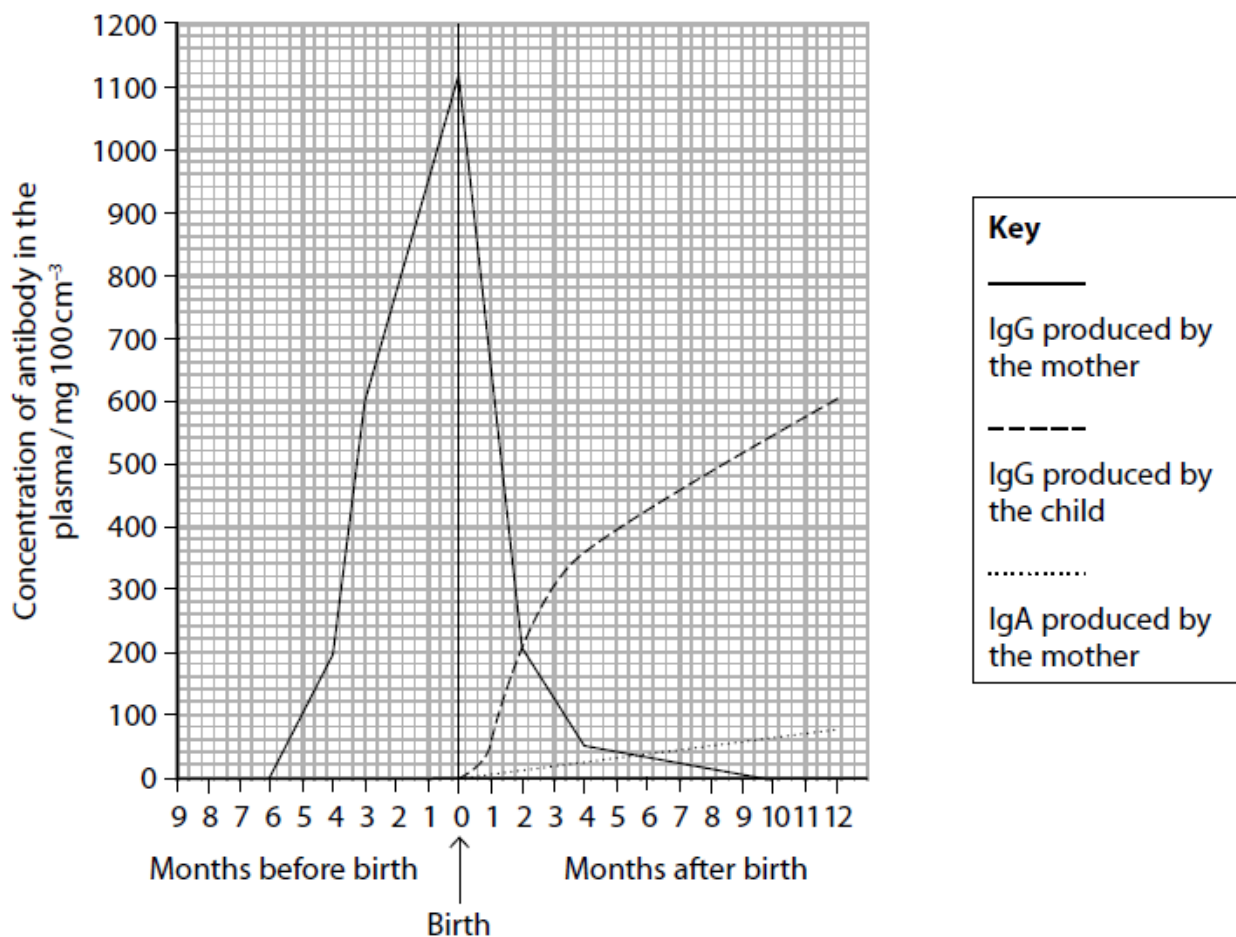
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(b) There are different classes of antibody, including IgA, IgG and IgM.

The graph shows the changes in the concentration of IgA and IgG in the plasma of a fetus before birth and in a child after birth.



(i) Describe the changes in the classes of antibody in a fetus before birth and in a child after birth. Use the information in the graph to support your answer.

(3)

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(ii) Which type of immunity explains the presence of IgA?

(1)

- ☐ **A** artificial active
- ☐ **B** artificial passive

- ☐ **C** natural active
- ☐ **D** natural passive

(iii) Suggest why the concentration of antibodies is less in a child 12 months after birth than in an adult.

(2)

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**(Total for question = 10 marks)**

Q4.

Rheumatoid arthritis is an inflammatory condition caused by the overactivity of the immune system.

(a) The photographs show the hand of a person with rheumatoid arthritis and the hand of a person without rheumatoid arthritis.



(Source: © Mediscan/Alamy Stock Photo)

Hand with rheumatoid arthritis

Magnification  $\times 0.2$

Hand without rheumatoid arthritis

Magnification  $\times 0.2$

(i) Give **one** piece of evidence, shown in the photographs, that rheumatoid arthritis is an inflammatory condition.

(1)

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(ii) Give **two other** signs of inflammation that are experienced in the hand of a person with rheumatoid arthritis.

(1)

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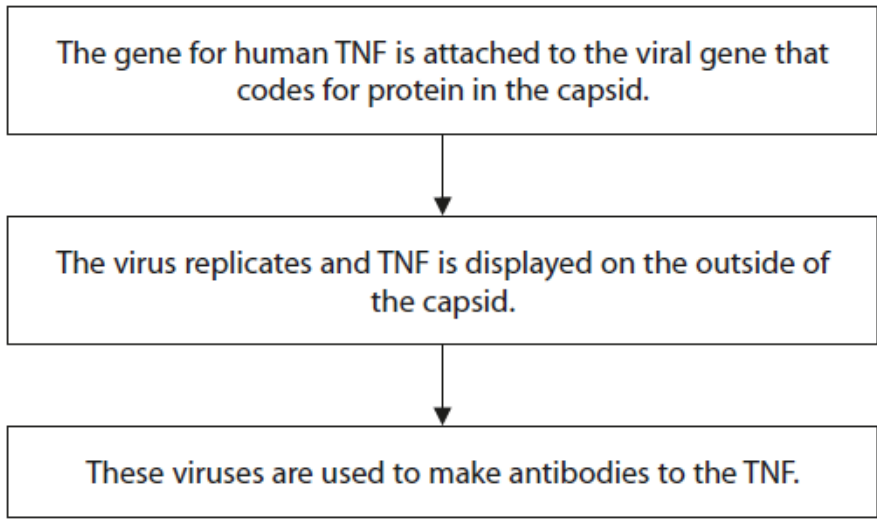
(b) Tumour necrosis factor (TNF) is a protein that can be released by several types of cell. It plays an important part in the immune response.

This protein binds to specific receptors on the surface of cell membranes stimulating chemical reactions inside the cell. As a result, a number of responses may occur that include inflammation and the stimulation of phagocytosis by macrophages.

Antibodies to TNF are used to treat rheumatoid arthritis.

Scientists have used a virus that infects bacteria to produce antibodies to human TNF.

The diagram summarises this process.



(i) Explain how attaching the gene for TNF to the viral gene results in TNF being displayed on the outside of the capsid.

(2)

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(ii) Explain why antibodies to TNF are used in the treatment of rheumatoid arthritis.

(2)

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(iii) Patients being treated with antibodies to TNF are more susceptible to tuberculosis (TB), which can be fatal.

Explain why patients being treated with antibodies to TNF can die from TB.

(4)

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(Total for question = 10 marks)

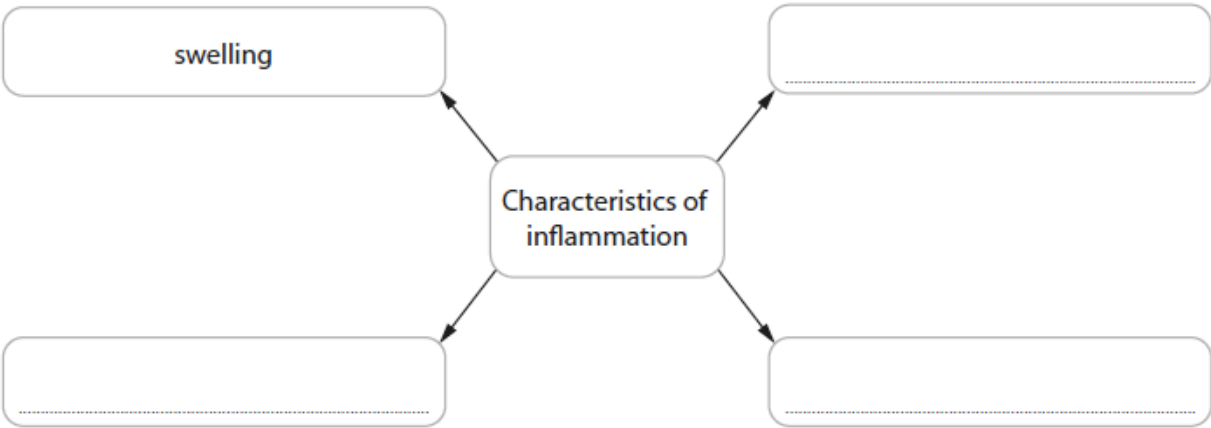
Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

Inflammation is involved in the non-specific response of the body to infection and injury.

(a) (i) Complete the diagram to show the four characteristics of inflammation.

(2)



(ii) Inflammation occurs following a cut to the skin.

Describe the role of **two** of these characteristics of inflammation in response to a cut to the skin.

(2)

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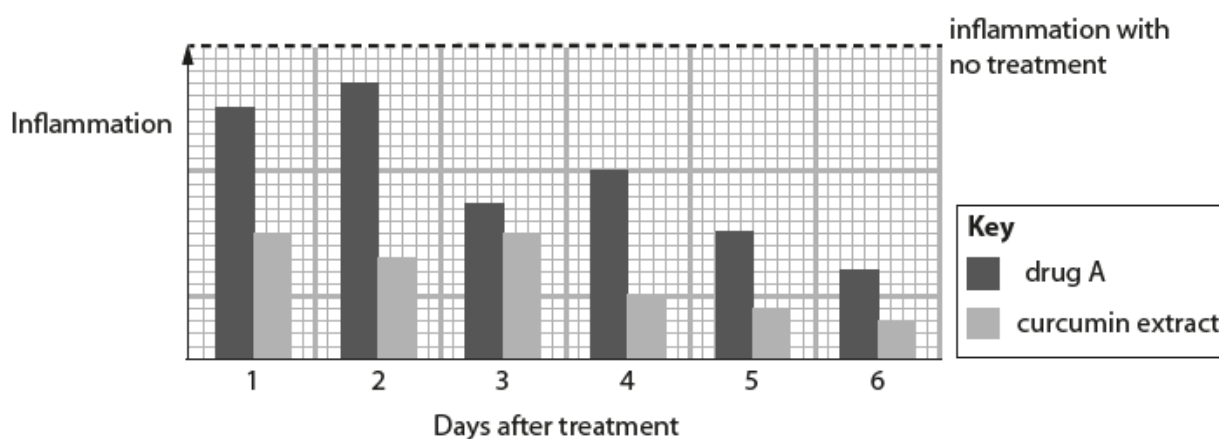
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(b) Anti-inflammatory drugs reduce inflammation.

Turmeric is a spice that is added to food.

Curcumin is a chemical in turmeric that has been shown to reduce inflammation.

(i) The graph shows the effect of treating inflammation with curcumin extract and an anti-inflammatory drug, drug A.



Compare and contrast the effect of treating inflammation with curcumin extract and with drug A.

(3)

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(ii) Many treatments use 1 g curcumin extract.

A sample of turmeric contains 3 % curcumin.

Which is the mass of turmeric for one treatment?

(1)

☐ **A** 0.03 g

☐ **B** 3.33 g

☐ **C** 33.3 g

☐ **D** 33.4 g

**(Total for question = 8 marks)**

Q6.

Some disorders are caused by mutations in the mitochondrial DNA and can be inherited.

Three-parent embryos have been developed to prevent the inheritance of these disorders.

Diagram 1 shows how three-parent embryos are made.

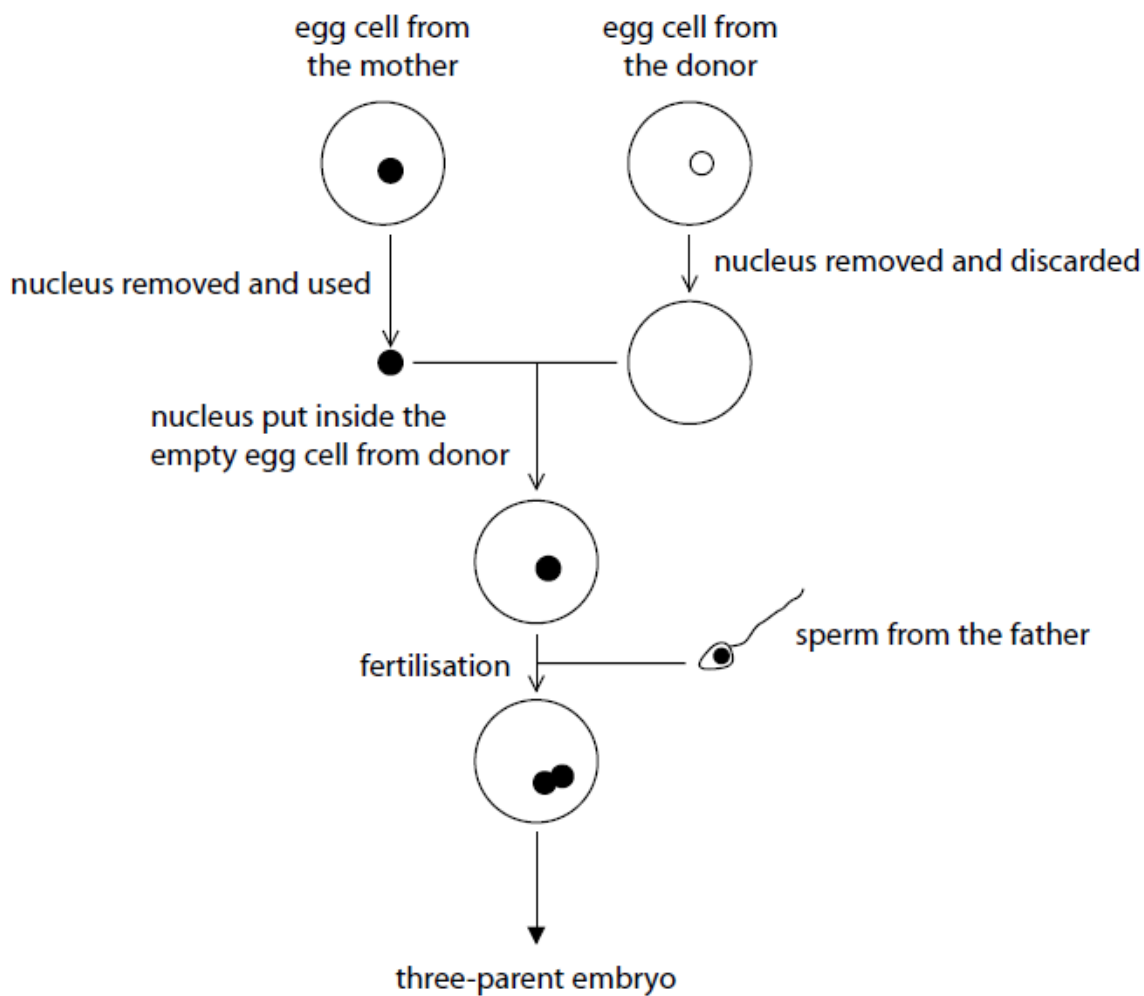


**Diagram 1**

(a) The cells in the three-parent embryo are totipotent stem cells.

State what is meant by the term **totipotent stem cells**.

(2)

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(b) Diagram 2 shows the results of separating the DNA from the three-parent embryo, the mother and the father, using gel electrophoresis.

The bands from the DNA of the embryo are labelled from 1 to 12.

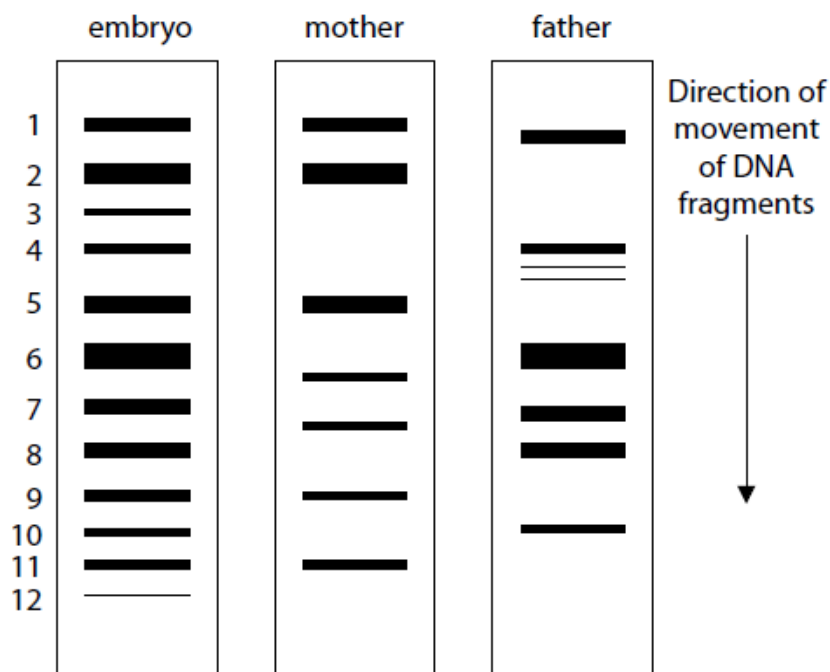


**Diagram 2**

(i) Which of the following is the reason for the movement of the DNA fragments?

(1)

- ☐ **A** negatively-charged fragments move towards the negative end of the gel
- ☐ **B** negatively-charged fragments move towards the positive end of the gel
- ☐ **C** positively-charged fragments move towards the negative end of the gel
- ☐ **D** positively-charged fragments move towards the positive end of the gel

(ii) Which band on the gel contains the heaviest DNA fragments?

(1)

- ☐ **A** 1
- ☐ **B** 3
- ☐ **C** 6
- ☐ **D** 9

\*(iii) Explain the banding pattern of this three-parent embryo. Use information in Diagram 1 and Diagram 2 to support your answer.

(6)

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**(Total for question = 10 marks)**

Q7.

Malaysia is covered by large areas of rainforest. These rainforests have one of the highest biodiversities in the world.

However, the rate of loss of rainforest in Malaysia is one of the highest in the world.

(a) (i) From 2000 to 2012, Malaysia lost 14.4% of its rainforest. This is equivalent to 47 278 km<sup>2</sup>.

Calculate the area of Malaysia covered by rainforest in 2000.

Give your answer in standard form.

**(3)**

Answer ..... km<sup>2</sup>

(ii) A decrease in the area covered by rainforest results in both a decrease in biodiversity and a decrease in populations.

Explain why a decrease in the area covered by rainforest reduces both biodiversity and populations within the rainforest.

(2)

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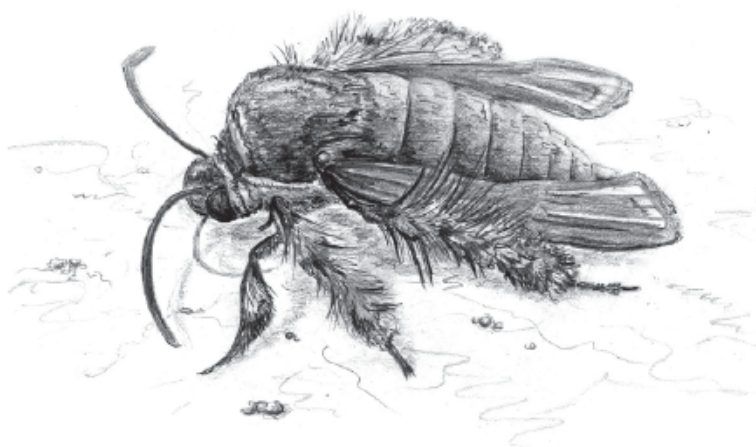
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(b) The diagram shows an Oriental blue clearwing, a species of moth found in the rainforests of Malaysia.



Magnification  $\times 5$

The Oriental blue clearwing has blue bands on its body. It resembles a bee by having transparent wings and fur on its body. It drinks in puddles of water where a number of species of bee also drink.

(i) Explain which examples of adaptation are illustrated by this moth.

(2)

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(ii) Suggest **two** advantages to the Oriental blue clearwing of resembling bees.

(2)

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(iii) This moth was seen and a specimen collected in 1887. It was not seen again in the rainforests of Malaysia until 2017.

The DNA of these recently rediscovered Oriental blue clearwings was compared with the DNA of the moth collected in 1887.

Describe how this comparison could be made.

(3)

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**(Total for question = 12 marks)**

Q8.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Antibiotics are medicines used to treat some medical conditions.

(a) The table shows some medical conditions and whether or not antibiotics are needed to treat the condition.

| Medical condition     | Are antibiotics needed to treat the condition? |
|-----------------------|------------------------------------------------|
| Impetigo              | yes                                            |
| Whooping cough        | yes                                            |
| Middle ear infections | sometimes                                      |
| Sinus infections      | sometimes                                      |
| Multiple sclerosis    | no                                             |
| Rheumatoid arthritis  | no                                             |

Explain the use of antibiotics to treat these conditions.

(2)

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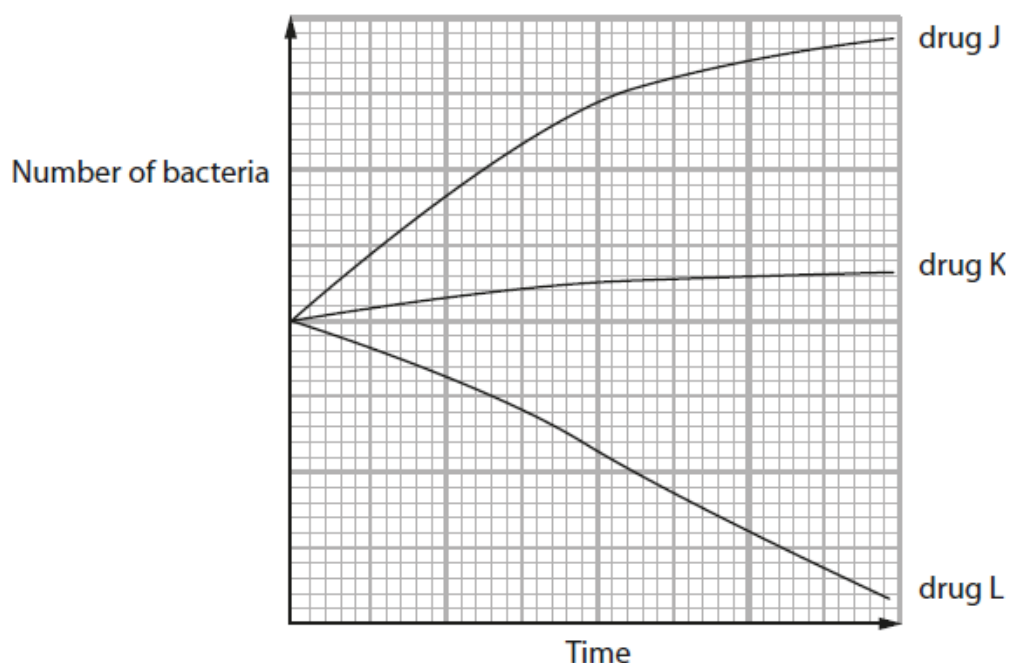
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(b) The graph shows the effect of three drugs, J, K and L, on the number of bacteria in a culture.



Which row of the table describes each of these three drugs?

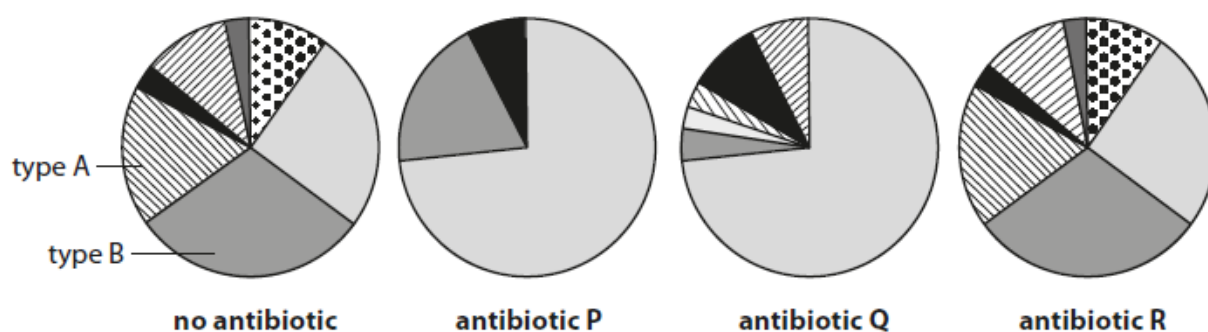
(1)

|                            | drug J                    | drug K                    | drug L                    |
|----------------------------|---------------------------|---------------------------|---------------------------|
| <input type="checkbox"/> A | not an antibiotic         | bactericidal antibiotic   | bacteriostatic antibiotic |
| <input type="checkbox"/> B | not an antibiotic         | bacteriostatic antibiotic | bactericidal antibiotic   |
| <input type="checkbox"/> C | bactericidal antibiotic   | not an antibiotic         | bacteriostatic antibiotic |
| <input type="checkbox"/> D | bacteriostatic antibiotic | not an antibiotic         | bactericidal antibiotic   |

(c) One problem of taking antibiotics is their effect on gut flora.

The diagrams show the effects of three antibiotics, P, Q and R, on the proportion of different types of gut flora.

Each section in each of the diagrams represents a different type of gut flora.



(i) Explain the role of gut flora in protecting the body from infection.

(2)

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(ii) Explain why antibiotics can affect gut flora.

(2)

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(iii) The number of type A in gut flora in the absence of antibiotics is 6 000 000.

Estimate the number of type B in gut flora in the absence of antibiotics.

Give your answer in standard form.

(1)

Answer .....

(iv) Deduce the effects of antibiotics P, Q and R on gut flora.

(3)

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**(Total for question = 11 marks)**

Q9.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is a disease causing worldwide concerns.

Methicillin is one of the antibiotics to which this pathogen has developed resistance.

Castaneroxy A is a molecule extracted from the European chestnut tree, endemic to Southern Europe and Turkey.

The effects of Castaneroxy A have been investigated.

The investigations have found that Castaneroxy A:

- does not affect the natural skin flora
- prevents MRSA from producing toxins
- weakens the MRSA bacteria
- reduces the size of skin infections caused by MRSA.

(a) Explain why the development of this drug is an example of an 'evolutionary race' between humans and this pathogen.

**(2)**

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(b) Explain why it is important that Castaneroxy A does not affect skin flora.

**(2)**

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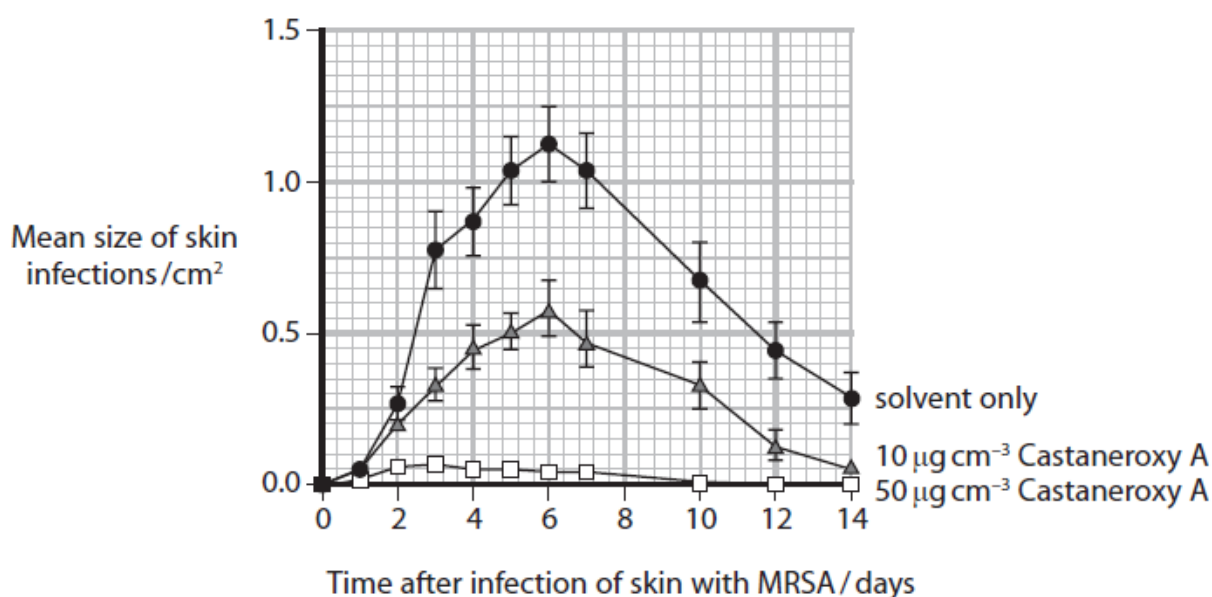
(c) Suggest how weakening the MRSA bacteria could help the recovery of a patient infected with this bacteria.

(2)

(d) In an investigation, patients who had developed skin infections were divided into three groups.

Two groups were each treated with a different concentration of Castaneroxy A. The other group was treated with only the solvent that was used in the treatment.

The graph shows the results of these treatments on the mean size of the skin infections.



(i) Explain why this investigation included treatment with the solvent only.

(2)

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(ii) Determine the effect that Castaneroxy A has on the mean size of skin infections.

(3)

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(iii) The leaves of the chestnut tree contain 0.0019 %, by mass, of Castaneroxy A.

Calculate the mass of leaves, in kilograms, that would be needed to produce 1 dm<sup>3</sup> of Castaneroxy A at a concentration of 50 µg cm<sup>-3</sup>.

Give your answer to the nearest kilogram.

(3)

Answer ..... kg

**(Total for question = 14 marks)**

Q10.

The photographs show a Northwestern crow and an American crow.



(Source: © All Canada Photos / Alamy Stock Photo)



(Source: © MichaelGrantBirds / Alamy Stock Photo)

These two crows look very similar and are therefore difficult to distinguish as two separate species.

Scientists have studied the nuclear DNA and the mitochondrial DNA (mtDNA) of these two species of birds.

(a) Give **two** differences between the structure of nuclear DNA and mtDNA.

(2)

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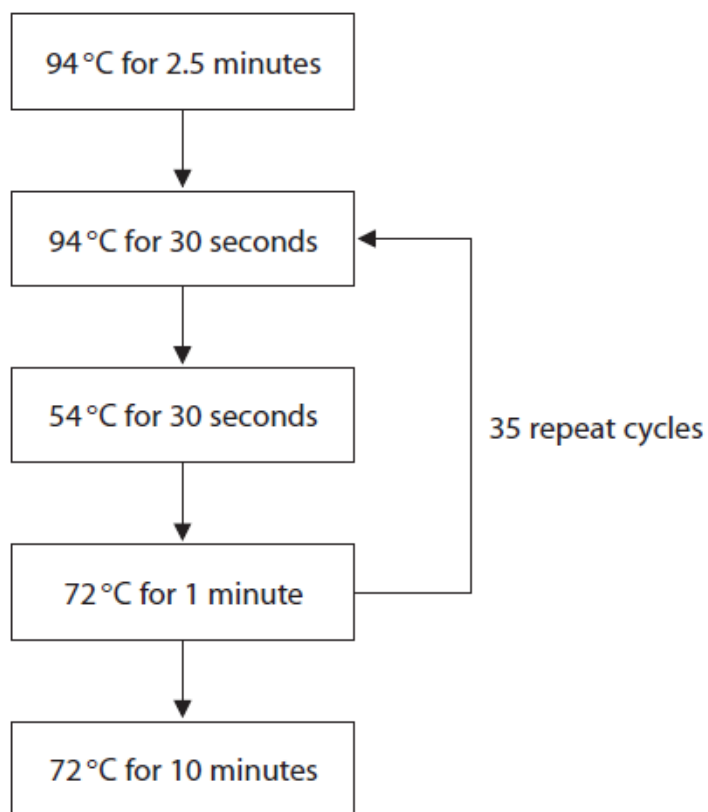
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(b) The mtDNA was isolated from these two species of crow and amplified using the polymerase chain reaction (PCR).

The diagram shows details of the process used.



(i) Name **three** molecules, other than the mtDNA and water, that would be needed in this process.

(2)

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(ii) Calculate the total length of time, in hours, that this process would take.

Give your answer to two decimal places.

(2)

Answer ..... hours

(iii) Explain how this process amplifies the DNA.

Use information in the diagram to support your answer.

(3)

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(c) Explain how the amplified mtDNA could be used to determine the genetic relationships between these two species of crow.

(3)

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(Total for question = 12 marks)

Q11.

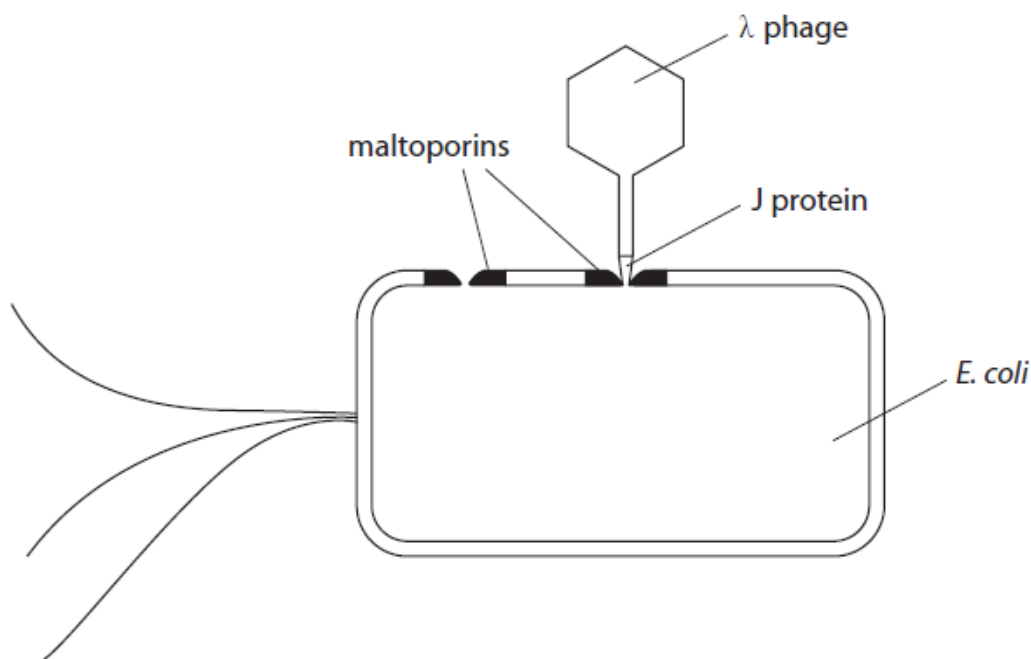
**Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

Pathogens continuously adapt to invade their host cells.

Host cells continuously adapt to avoid infection by pathogens.

This is an example of an 'evolutionary race'.

The diagram shows the pathogen lambda phage ( $\lambda$  phage) attached to its host cell, *E. coli*.



(a) How many of the following statements are correct for  $\lambda$  phage?

- the genetic material is DNA
- the capsid structure is described as complex
- the genetic material codes for the J protein

(1)

- ☐ **A** 0
- ☐ **B** 1
- ☐ **C** 2
- ☐ **D** 3

(b) Describe the role of the  $\lambda$  phage J protein.

Use the information in the diagram to support your answer.

(2)

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(c) Maltoporin is coded for by the *lam $\beta$*  gene of *E. coli*.

Maltoporin is involved in the transport of some sugars into *E. coli*.

(i) Give **one** reason why sugars are important to *E. coli*.

(1)

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\*(ii) Discuss how *E. coli* and  $\lambda$  phage could interact and develop in their evolutionary race for existence.

Use the information in this question to support your answer.

(6)

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(Total for question = 10 marks)

Q12.

Plastics are carbon-based polymers made from repeating monomers.

Many plastics do not break down naturally and their disposal is causing a lot of damage to the environment.

(a) Plastics have been around for about 70 years.

Scientists think that microorganisms could evolve the ability to break down plastics to obtain nutrients.

(i) Explain why scientists think that plastics could be broken down by microorganisms.

(2)

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(ii) Explain how microorganisms could evolve to break down plastics.

(3)

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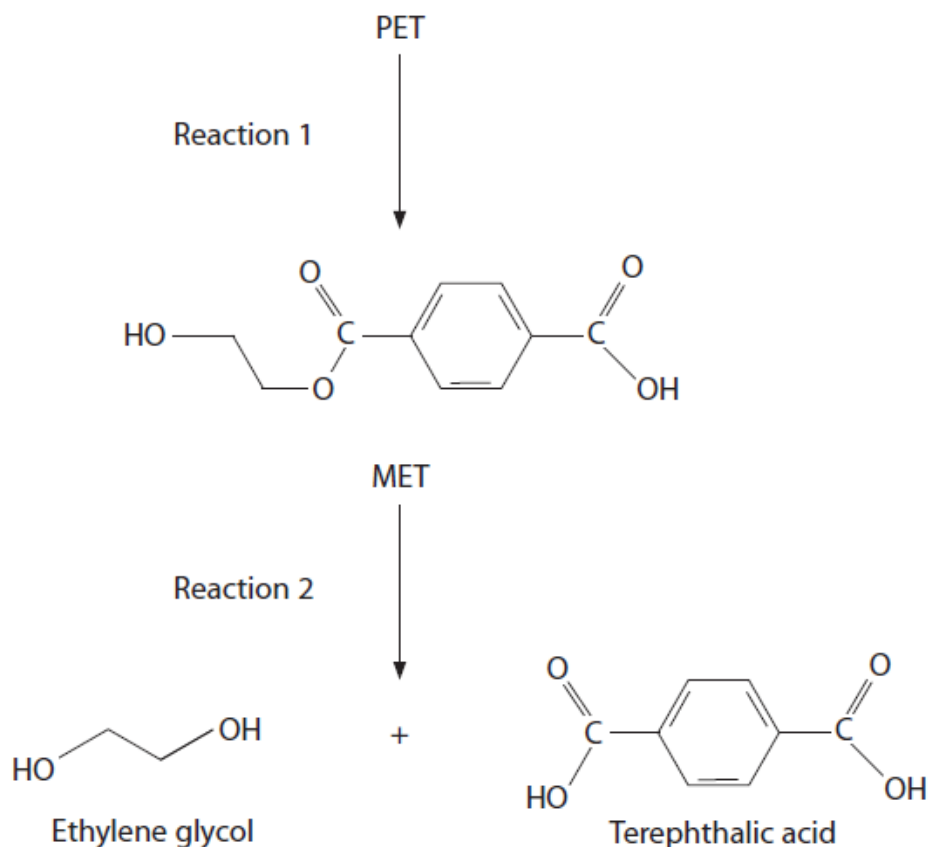
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(b) Some bacteria have been discovered that can break down one type of plastic, the polymer polyethylene terephthalate (PET).

This polymer is made from the monomer ethylene terephthalate (MET).

The diagram shows how PET can be broken down.



Which row of the table describes reaction 1 and reaction 2?

(1)

|                            | Reaction 1   | Reaction 2   |
|----------------------------|--------------|--------------|
| <input type="checkbox"/> A | condensation | condensation |
| <input type="checkbox"/> B | condensation | hydrolysis   |
| <input type="checkbox"/> C | hydrolysis   | condensation |
| <input type="checkbox"/> D | hydrolysis   | hydrolysis   |

(Total for question = 6 marks)

Q13.

The presence of skin flora is one way that the skin protects the body from infection.

(a) (i) Describe how skin flora protect the body from infection.

(2)

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(ii) Give **one** other way in which the skin protects the body from infection.

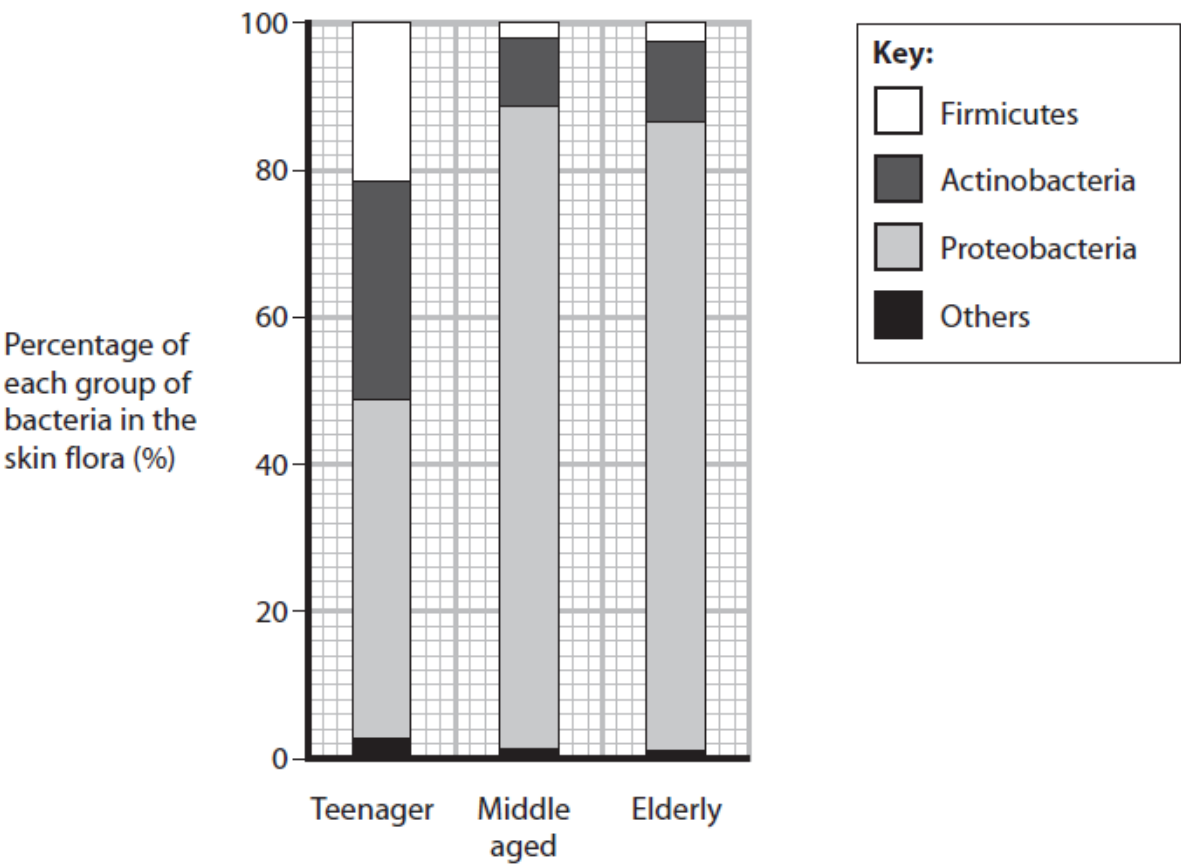
(1)

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(b) The groups of bacteria present on the skin of men of different ages was investigated. The graph shows some of the results of this investigation.



(i) Describe **three** conclusions that could be made from this graph.

(3)

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(ii) Describe how this study should have been designed to collect valid data.

(2)

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(c) Some bacteria can get through the skin.

(i) Describe the role of macrophages in the non-specific response of the body to these bacteria.

(2)

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(ii) Describe the role of macrophages in the immune response of the body to these bacteria.

(2)

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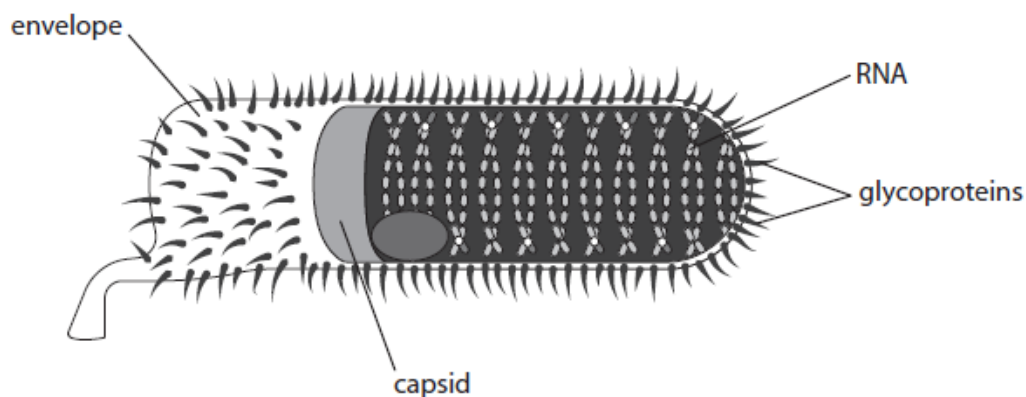
(Total for question = 12 marks)

Q14.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Rabies is a disease caused by a virus.

(a) The diagram shows the structure of the rabies virus.



(i) The rabies virus has an envelope.

Which of the following pairs of viruses have an envelope?

(1)

- ☐ **A** Ebola virus and human immunodeficiency virus (HIV)
- ☐ **B** human immunodeficiency virus (HIV) and tobacco mosaic virus (TMV)
- ☐ **C** lambda phage ( $\lambda$  phage) and Ebola virus
- ☐ **D** tobacco mosaic virus (TMV) and lambda phage ( $\lambda$  phage)

(ii) The structure of the rabies capsid is described as complex.

Which of the following has a complex capsid structure?

(1)

- ☐ **A** Ebola virus
- ☐ **B** human immunodeficiency virus (HIV)
- ☐ **C** lambda phage ( $\lambda$  phage)
- ☐ **D** tobacco mosaic virus (TMV)

(iii) Rabies virus is an RNA virus.

How many of the following viruses are RNA viruses?

- Ebola virus
- human immunodeficiency virus (HIV)
- lambda phage ( $\lambda$  phage)
- tobacco mosaic virus (TMV)

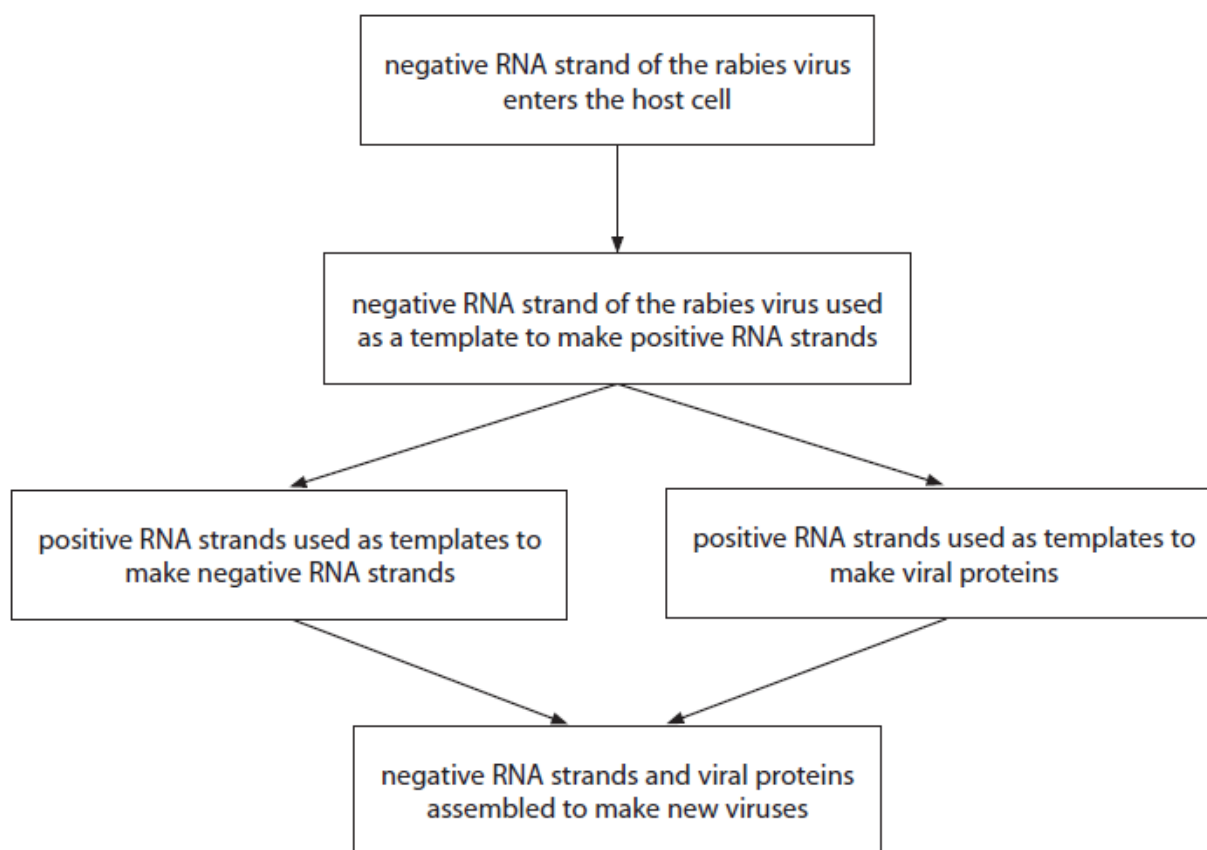
(1)

- ☐ **A** 1
- ☐ **B** 2
- ☐ **C** 3
- ☐ **D** 4

(b) The rabies virus replicates in a lytic cycle.

The RNA of the rabies virus is a negative RNA strand.

The diagram shows how the negative RNA strand of the rabies virus is used to make positive RNA and proteins.



(i) The diagram shows part of the base sequence in the negative RNA strand.

Complete the diagram to show the corresponding base sequence in the positive RNA strand.

(1)

|                            |          |          |          |          |          |          |          |          |          |
|----------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>Negative RNA strand</b> | <b>A</b> | <b>C</b> | <b>C</b> | <b>A</b> | <b>A</b> | <b>G</b> | <b>G</b> | <b>C</b> | <b>G</b> |
| <b>Positive RNA strand</b> |          |          |          |          |          |          |          |          |          |

(ii) Explain why a positive RNA strand has to be made.

(2)

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(c) Lemurs are found in Madagascar. It is thought that they might carry rabies viruses.

The photograph shows a lemur.



(Source: Caroline Wilcox)

A person was bitten by a lemur.

This person did not receive any treatment for rabies until 18 days after being bitten.

Explain why doctors were worried that this person had left it too long for the treatment to be successful.

(4)

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**(Total for question = 10 marks)**

Q15.

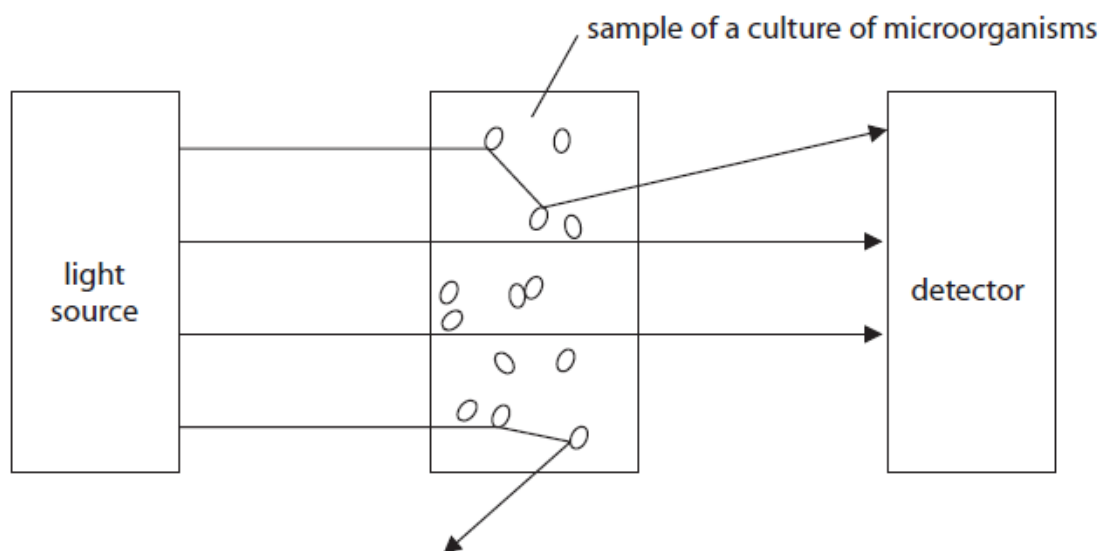
The growth of microorganisms can be studied using optical methods (turbidity).

The number of cells in  $1\text{ cm}^3$  of a culture can be estimated by using a photometer to measure the optical density of the culture.

Light is shone through a sample of the culture and a detector records the optical density.

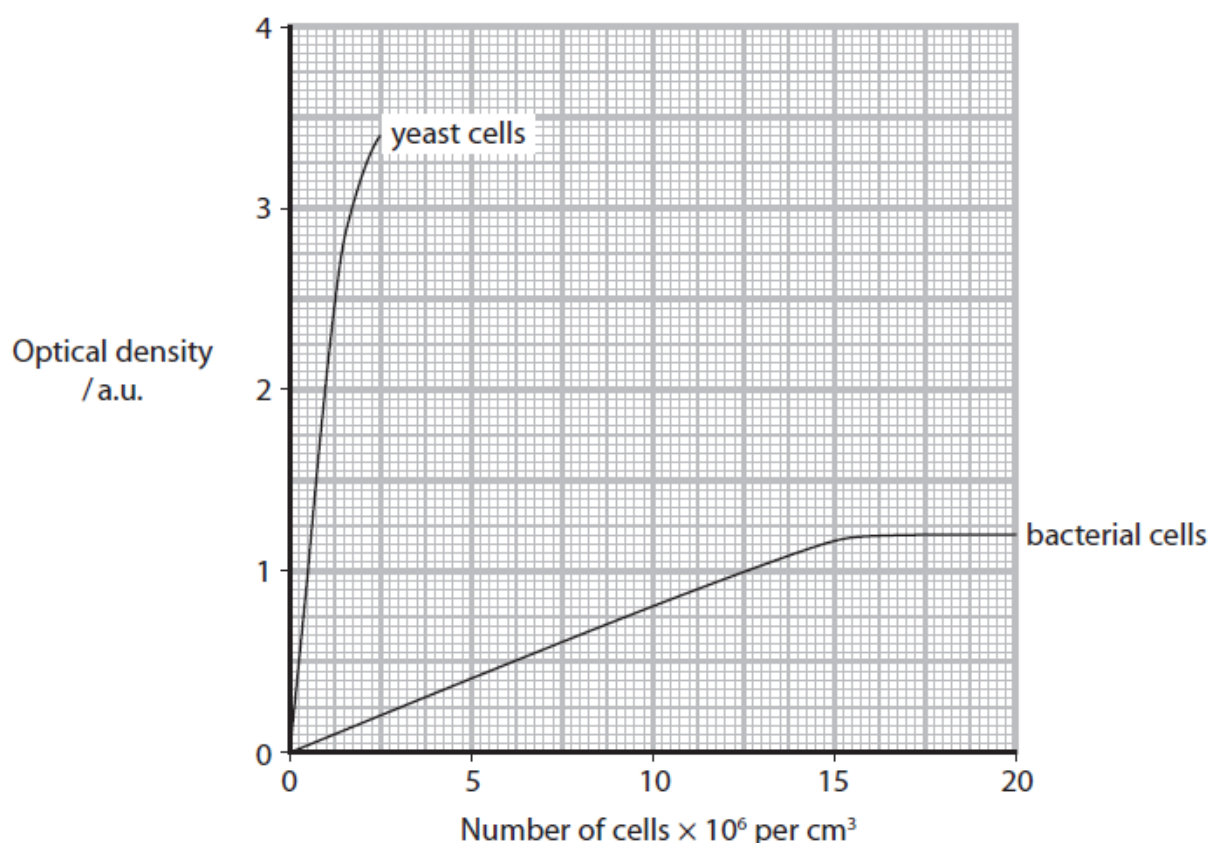
The more light absorbed by the culture, the higher the optical density.

The diagram shows what happens to light shone at a culture of microorganisms.

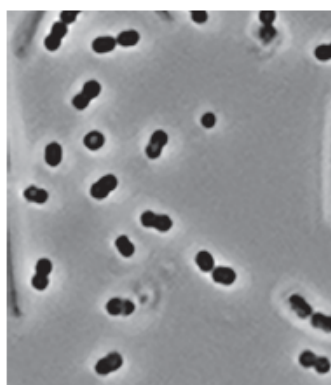


The number of cells in the sample is determined using a calibration curve.

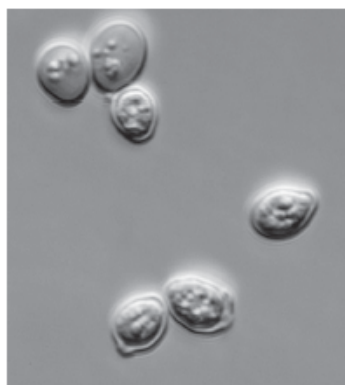
The graph shows a calibration curve for bacterial cells and yeast cells.



The photographs show bacterial cells and yeast cells, as seen using a light microscope.



bacterial cells



yeast cells

scale:  $5\ \mu\text{m}$

© WIM VAN EGMOND/  
SCIENCE PHOTO LIBRARY

©Uncia/Shutterstock

(a) State the relationship between optical density and the size of the microorganisms.

(1)

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(b) Calculate how many times more bacterial cells there are than yeast cells if both samples have an optical density of 1.0 a.u.

(2)

Answer .....

(c) (i) State the relationship between the number of bacterial cells and optical density.

(1)

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(ii) Suggest why using optical density to measure the concentration of microorganisms is more accurate at lower concentrations of cells.

Use the information in the diagram to support your answer.

(2)

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**(Total for question = 15 marks)**

Q16.

The photograph shows a Tasmanian devil.



(Source: © Walter 64 / Alamy Stock Photo)

Tasmanian devils are found in Tasmania.

The population of Tasmanian devils has fallen drastically due to a fatal cancer.  
This cancer first appeared in the mid-1990s.

There are only a few regions in Tasmania left where healthy Tasmanian devils can still be found.

(a) The number of Tasmanian devils is estimated to have fallen from 150 000 in the mid-1990s to 25 000 in 2020.

Calculate the percentage decrease in the number of Tasmanian devils from the mid-1990s to 2020.

Answer ..... %

(b) Tasmanian devils feed on the dead bodies of animals (carcasses) and scare off other scavengers.

Scientists have studied the scavenging of carcasses in two regions of Tasmania: one region where all Tasmanian devils were healthy and one region where the cancer was common.

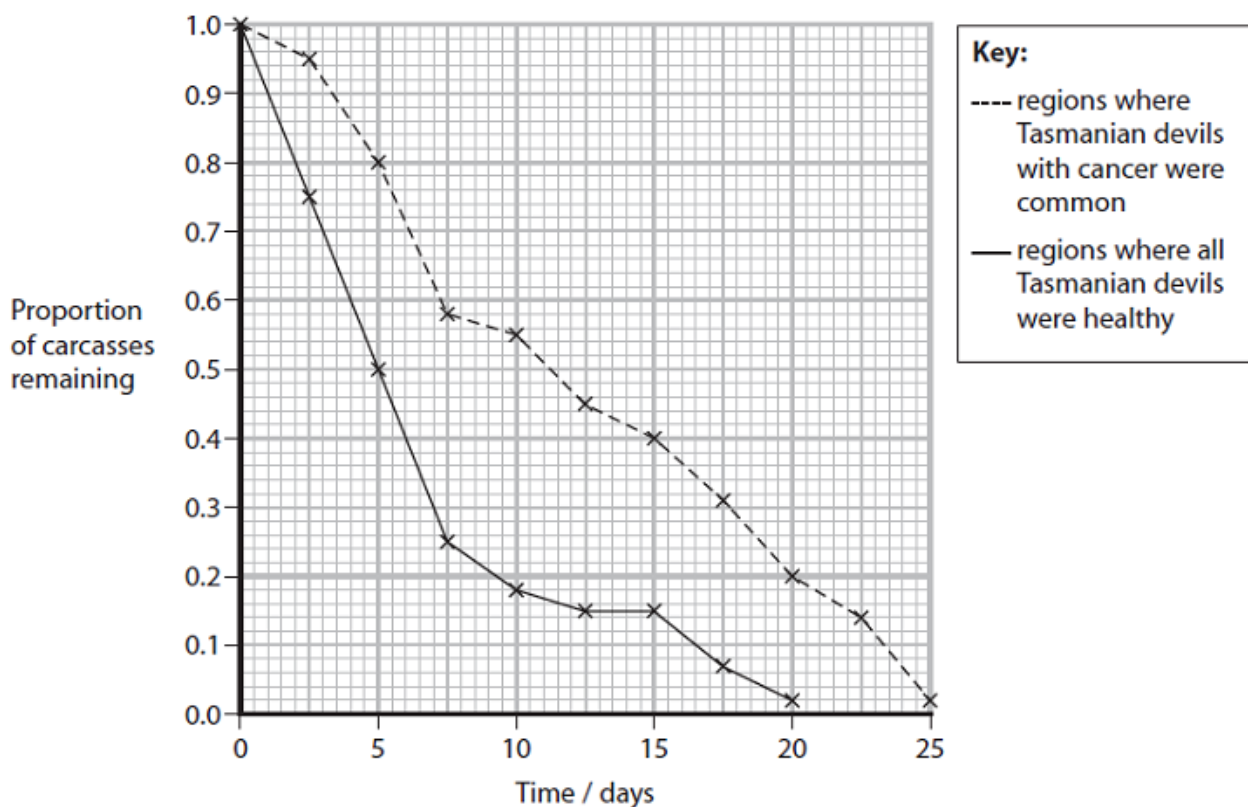
The length of time Tasmanian devils and three other scavenging animals spent feeding on carcasses was investigated.

The results are shown in the table.

| Region                                         | Proportion of time the scavengers spent feeding on each carcass |              |                      |           |
|------------------------------------------------|-----------------------------------------------------------------|--------------|----------------------|-----------|
|                                                | Tasmanian devil                                                 | Forest raven | Spotted-tailed quoll | Feral cat |
| Where all Tasmanian devils were healthy        | 0.76                                                            | 0.13         | 0.06                 | 0.05      |
| Where Tasmanian devils with cancer were common | 0.26                                                            | 0.38         | 0.20                 | 0.16      |

The length of time it took for the carcasses to be completely eaten was also investigated.

The results are shown in the graph.



\*(i) Explain the results of these two studies.

Use the information in the table and the graph to support your answer.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(ii) Explain what other **biotic** factors could have affected the results from the two different regions of Tasmania, in the second investigation.

(4)

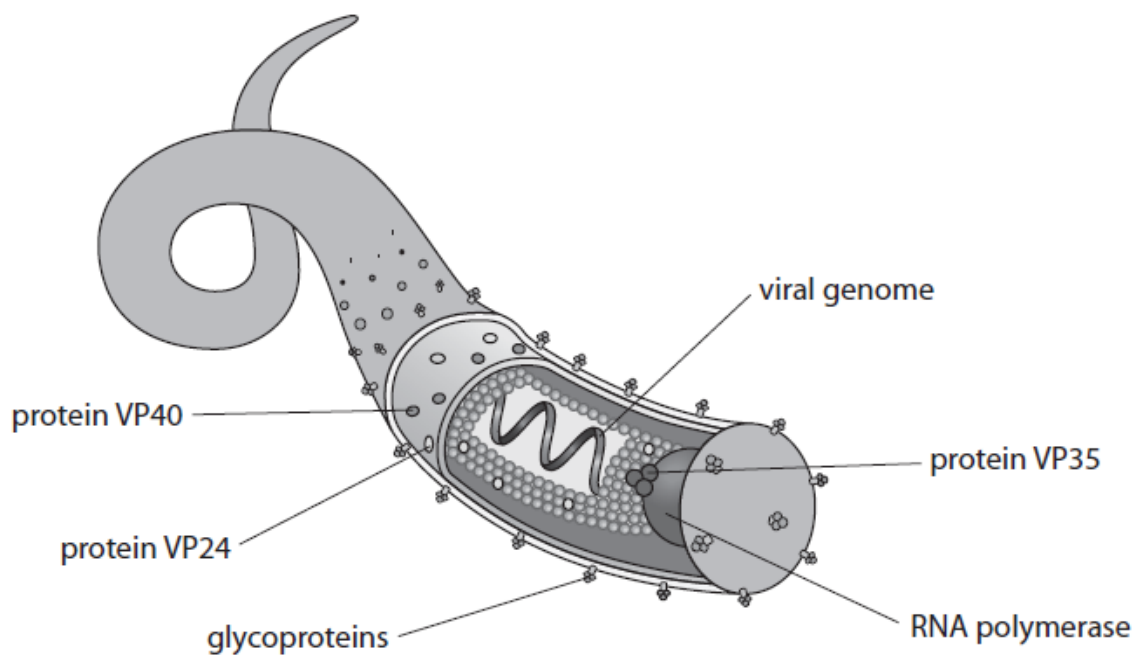
[illegible]

(Total for question = 11 marks)

Q17.

In December 2018 there was an outbreak of Ebola, with 500 cases being reported.

The diagram shows the structure of an Ebola virus.



(a) Describe the role of each of the following.

(i) The viral genome

(2)

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(ii) The glycoproteins

(2)

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(b) The enzyme RNA polymerase is involved in RNA transcription.

Explain why the structure of the Ebola virus includes RNA polymerase.

(2)

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(c) The proteins VP24 and VP40 are involved in virus assembly.

State what is meant by the term virus assembly, using Ebola as an example.

(2)

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(d) The protein VP35 inhibits the production of interferon by host cells.

Explain why the structure of the Ebola virus includes VP35.

(2)

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**(Total for question = 10 marks)**

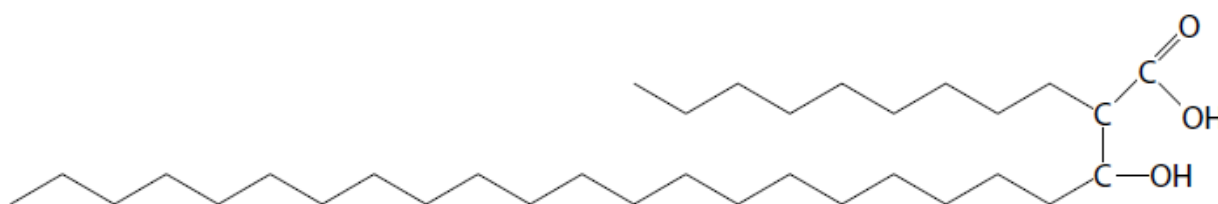
Q18.

Tuberculosis is a disease caused by infection with *Mycobacterium tuberculosis*.

The cell wall of *M. tuberculosis* is different from most other types of bacteria as it contains different types of mycolic acid.

Mycolic acid protects the bacteria from lysozyme action, dehydration and polar (hydrophilic) antibiotics.

The diagram shows part of one type of mycolic acid.



(a) What type of molecule is mycolic acid?

(1)

- ☐ **A** carbohydrate
- ☐ **B** fatty acid
- ☐ **C** nucleic acid
- ☐ **D** polypeptide

(b) Treatment for tuberculosis involves the use of different types of antibiotic, taken over several months.

The table gives details of four antibiotics used to treat tuberculosis.

| Antibiotic | Mode of action                                                 |
|------------|----------------------------------------------------------------|
| E          | disrupts the formation of the cell wall                        |
| J          | inhibits the synthesis of mycolic acids                        |
| P          | activates an enzyme that inhibits the synthesis of fatty acids |
| R          | binds to the active site of RNA polymerase                     |

(i) Suggest why antibiotic E is effective only when *M. tuberculosis* bacteria are dividing.

(1)

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(ii) Explain why antibiotic J could result in an increase in antigen presentation by macrophages.

(2)

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(iii) Explain how antibiotic P could affect *M. tuberculosis*.

(3)

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(iv) Explain how antibiotic R could affect *M. tuberculosis*.

(3)

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(v) Explain why taking a combination of antibiotics for several months could increase the resistance of *M. tuberculosis* to these antibiotics.

(2)

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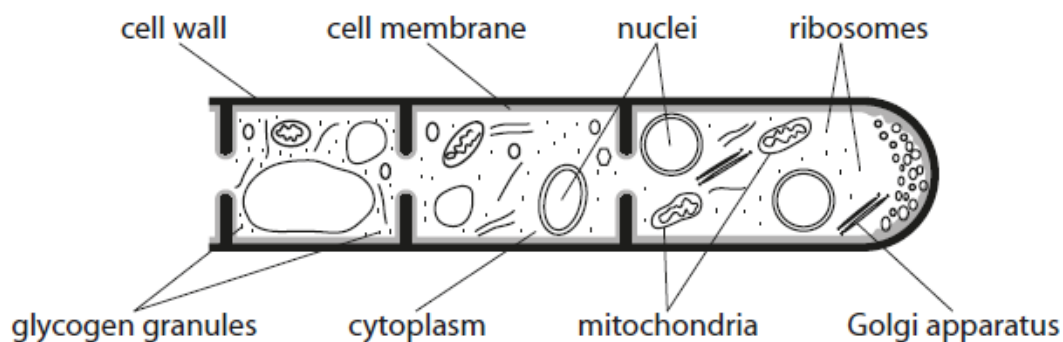
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**(Total for question = 12 marks)**

Bacteria and fungi can both cause infections.

(a) The diagram shows part of the structure of a fungus.



(i) How many of the organelles labelled in this diagram have membranes?

(1)

☐ **A** 1

☐ **B** 3

☐ **C** 5

☐ **D** 7

(ii) Explain why fungi are not classified as bacteria, plants or animals.

Use the information in the diagram and your knowledge of cell structure to support your answer.

(3)

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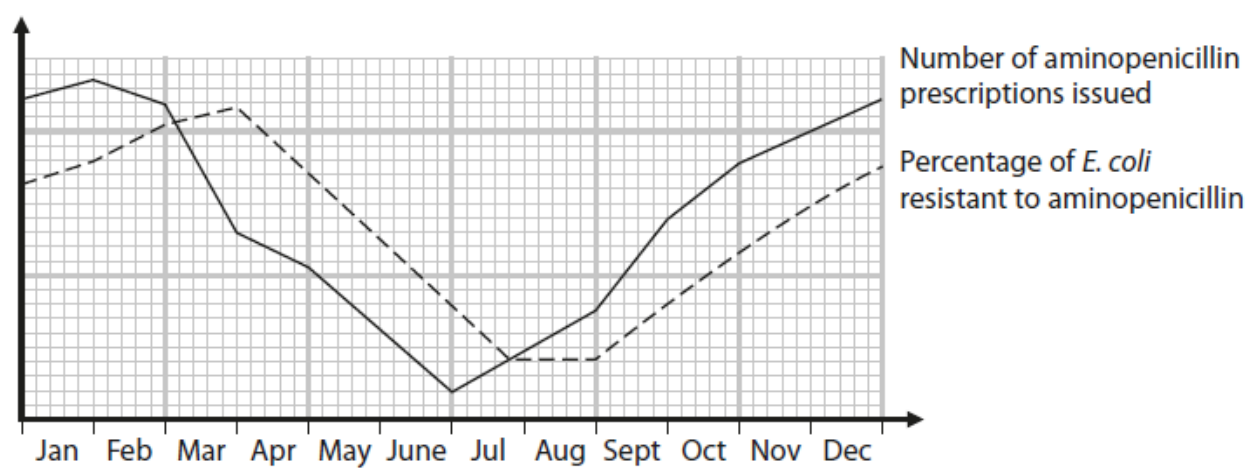
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(b) The graph shows the number of prescriptions of the antibiotic, aminopenicillin, issued in one year.

The graph also shows the percentage of *E. coli* bacteria that were resistant to aminopenicillin

during the same year.



Explain the relationship between the number of aminopenicillin prescriptions issued and the percentage of *E. coli* resistant to aminopenicillin during this one-year period.

Use the information in the graph to support your answer.

(4)

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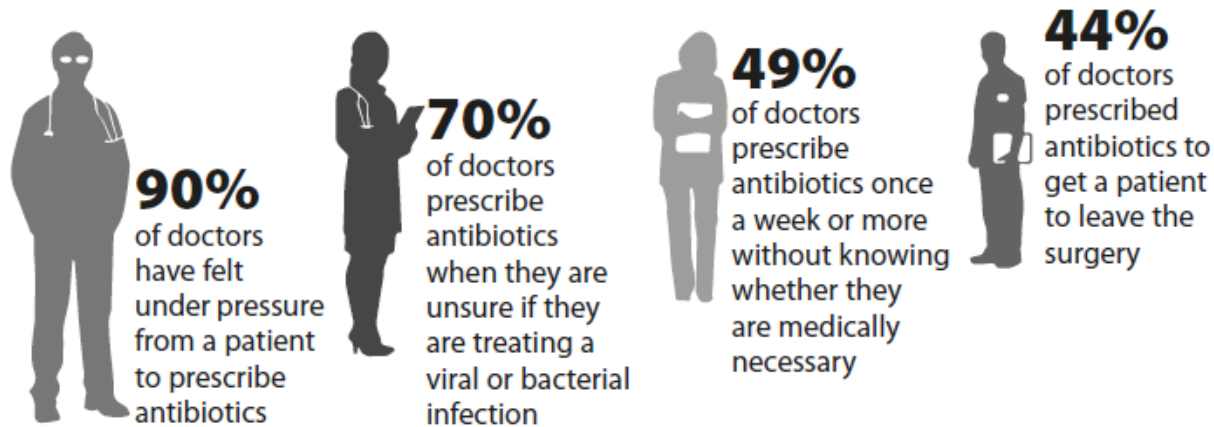
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(c) The results of a survey are shown in the diagram.



Explain why the results of this survey are a cause for concern.

(3)

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**(Total for question = 11 marks)**

Q20.

In 2018, an organisation carried out a global survey into the attitudes of people towards vaccines.

Vaccines provide artificial active immunity.

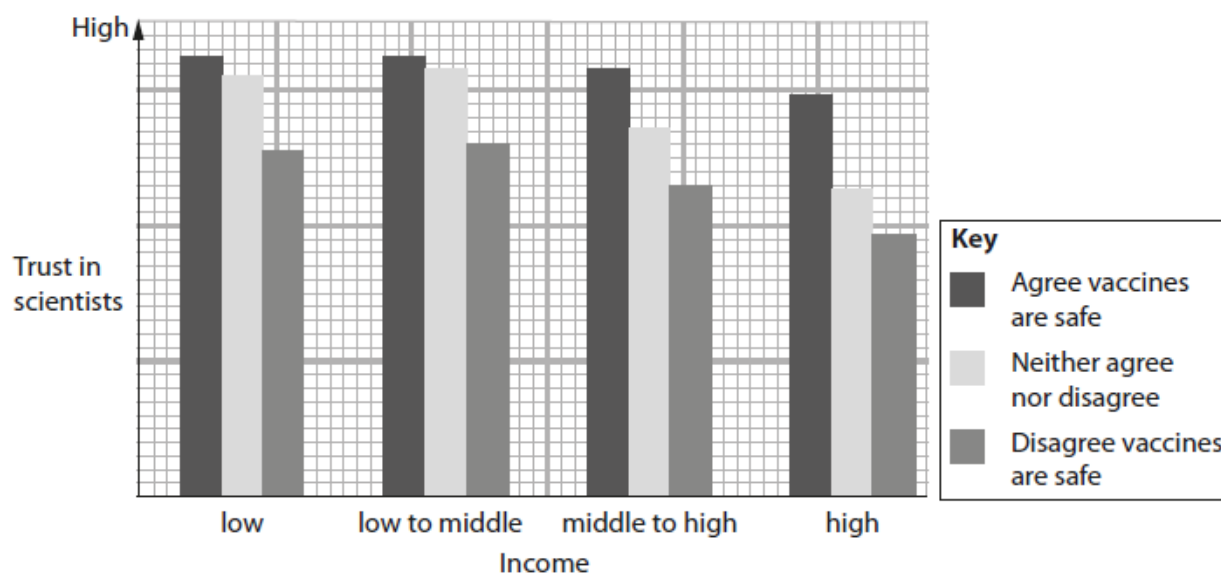
(a) Describe how a vaccine results in active immunity.

(4)

(b) This survey included three aspects:

- the trust that people have in scientists
- their thoughts on the safety of vaccines
- their income.

The graph shows some of the results of this survey.



(i) Identify **three** conclusions that can be drawn from the results of this survey.

(3)

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(ii) Suggest **one** reason for the different attitudes of these people.

(1)

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(c) The more people in a population who are vaccinated against a disease, the less likely it is for non-vaccinated people to become infected.

Suggest why vaccination is more successful when a greater proportion of people are vaccinated.

(2)

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**(Total for question = 10 marks)**

Q21.

Viruses can infect bacteria.

(a) Which virus can infect bacteria?

(1)

- ☐ **A** Ebola virus
- ☐ **B** human immunodeficiency virus (HIV)
- ☐ **C** lambda phage ( $\lambda$  phage)
- ☐ **D** tobacco mosaic virus (TMV)

(b) Some viruses that infect bacteria cause the production of molecules called holins.

Holins form protein channels in the cell membranes of bacteria. This allows polar molecules called lysins to reach the cell wall by facilitated diffusion.

The DNA of these viruses codes for lysins.

(i) Describe the role of channel proteins in the facilitated diffusion of lysins.

(2)

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(ii) Explain how the primary structure and the tertiary structure of holins determine the properties of these channel proteins.

(3)

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(iii) Lysins break down the cell wall of bacteria.

Explain the role of lysins in the lytic cycle.

(2)

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(Total for question = 8 marks)

Q22.

**Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.**

The following features of viruses can be used to classify them:

- the type of nucleic acid they contain
- the arrangement of the proteins in their capsid
- the presence or absence of an envelope
- the enzymes they contain.

(a) For each structure, put one cross ☐ in the appropriate box, in each row, to show which viruses have that structure.

(3)

| Structure      | Virus                    |                          |                                     |                                     |
|----------------|--------------------------|--------------------------|-------------------------------------|-------------------------------------|
|                | Ebola only               | HIV only                 | both Ebola and HIV                  | neither Ebola nor HIV               |
| DNA            | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| helical capsid | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| envelope       | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

(b) Human cells contain several types of DNA polymerase.

One type of DNA polymerase, found in some cancer cells, has been shown to synthesise DNA from an RNA template.

(i) Name the enzyme, found in some types of virus, that can synthesise DNA from an RNA template.

(1)

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(ii) Suggest why this DNA polymerase may be a target for drugs used to treat cancer.

(1)

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(Total for question = 5 marks)

**Mark Scheme**

Q1.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>C</p> <p>The only correct answer is C</p> <p><i>A is incorrect because macrophages present antigen to T helper cells</i><br/> <i>B is incorrect because macrophages present antigen to T helper cells and host-infected cells present antigen to T killer cells</i><br/> <i>D is incorrect because host-infected cells present antigen to T killer cells</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                         | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>The only correct answer is <b>B</b> Human immunodeficiency virus</p> <p><i>A is incorrect because Ebola infects endothelial cells and liver cells</i><br/> <i>C is incorrect because A phage infects bacteria</i><br/> <i>D is incorrect because TMV infects plants</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                           | Additional guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• T cells need to {express CAR gene / produce CAR receptor} (1)</li> <li>• in order to bind to the {tumour (cells) / tumour antigen / specific (tumour) antigen} (1)</li> </ul> | ACCEPT cancer       | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                               | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• to produce genetically-identical cells (1)</li> <li>• that will all have the {the CAR gene / CAR receptor} (1)</li> <li>• to increase the number of cells so that there are enough {for the treatment / to destroy the cancer cells} (1)</li> </ul> | <p>ACCEPT clones</p> <p>ACCEPT fast treatment</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                               | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iv)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>so that the patient will not have an immune response against the T cells (1)</li> <li>because there will not be any foreign <b>antigens</b> on the T cells (1)</li> <li>therefore the T cells will not be destroyed (1)</li> <li>to reduce the risk of transmitting pathogens / no need to take immunosuppressants / no need to find a donor (1)</li> </ul> | <p><b>ACCEPT</b> lower chance of rejection</p> <p><b>ACCEPT</b> will have same / self <b>antigens</b></p> <p><b>ACCEPT</b> description e.g engulfed, digested</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional guidance                                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(v)          | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>{CAR-T cell / CAR receptor} does not bind to {solid / other types of} tumour (1)</li> <li>{solid / other types of} tumours {do not have the specific <b>antigen</b> / have different <b>antigens</b>} (1)</li> <li>T cells are not able to reach the cancer cells / too many cancerous cells for the treatment to work (1)</li> </ul> | <p><b>ACCEPT</b> {CAR-T cell / CAR receptor} <b>only</b> bind to blood cell cancers</p> <p><b>ACCEPT only</b> blood cell tumours have the specific <b>antigen</b></p> <p><b>ACCEPT</b> reason why T cells cannot reach the cancer cells e.g T cells cannot leave the blood stream, solid tumours produce T cell inhibitors, no chemicals released to attract the T cells to the solid tumour</p> | (2)  |

Q2.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because it {destroys / weakens} the immune system (1)</li> <li>by {destroying / decreasing the number of} T helper cells (1)</li> <li>so {B cells / T killer cells} cannot be activated (1)</li> <li>credit a consequence of this (1)</li> </ul> | <p><b>ACCEPT</b> immunity</p> <p><b>ACCEPT</b> CD4 cells</p> <p><b>ACCEPT</b> {humoral / cell-mediated} immunity cannot be initiated</p> <p>e.g fewer antibodies produced (by plasma cells), less opsonisation, fewer infected host cells destroyed</p> <p><b>IGNORE</b> phagocytosis unless description of opsonisation</p> <p><b>DO NOT ACCEPT</b> viruses killed</p> <p><b>NB</b> max 3 marks if no context</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                                                        | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because if reverse transcriptase is inhibited, a DNA copy of the (viral) RNA cannot be made (1)</li> <li>because if integrase is inhibited, this DNA cannot be incorporated into the host cell DNA (1)</li> </ul> | <p><b>ACCEPT</b> (viral) DNA cannot be made</p> <p>(viral) RNA cannot be transcribed <u>into DNA</u></p> <p><b>DO NOT ACCEPT</b> RNA cannot be made into DNA</p> <p><b>ACCEPT</b> provirus cannot be formed</p> <p><b>NB both reasons given but not linked to each enzyme = 1 mark</b></p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                                                                                                                                         | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>to increase the likelihood of the drugs {being effective / destroying the virus} (1)</li> <li>credit an example of why they may not be effective on their own (1)</li> <li>maybe used to treat other (viral) infections (1)</li> </ul> | <p><b>ACCEPT</b> a description of how this could happen e.g.targetting another site (on the virus)</p> <p><b>DO NOT ACCEPT</b> kill the virus</p> <p><b>e.g.</b> one type of inhibitor may not penetrate all the cells</p> <p>virus may have mutated and become resistant</p> <p>other drugs might prevent the attachment of HIV to {host cells / T helper cells / CD4}</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                  | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>because the drug treatment does not completely remove the virus (1)</li> <li>therefore {viral replication can occur / activation of provirus} (1)</li> <li>new viral particles burst out of {host / T helper} cells (1)</li> </ul> | <p><b>ACCEPT</b> enter the lytic cycle<br/> <b>DO NOT ACCEPT</b> if linked to incorporation of DNA into host DNA</p> | (2)  |

Q3.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>each antibody can bind to two bacteria resulting in agglutination (1)</li> <li>antibody {can bind to both the phagocyte and the bacteria / causes opsonisation} (1)</li> <li>therefore phagocytosis is enhanced (1)</li> <li>toxins are neutralised (1)</li> </ul> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>IgG produced by mother increases in months before birth and then decreases after birth (1)</li> <li>IgG produced by child increases rapidly after birth (1)</li> <li>IgA increases slowly after birth (1)</li> </ul> | (3)  |

| Question number | Answer            | Mark |
|-----------------|-------------------|------|
| (b)(ii)         | D natural passive | (1)  |

| Question number | Answer                                                                                                                                                                                                                       | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>child has not been exposed to all types of antigen (1)</li> <li>no {IgM / other classes of antibody} produced yet (1)</li> </ul> | (2)  |

Q4.

| Question number | Answer                                                                       | Additional guidance                                  | Mark |
|-----------------|------------------------------------------------------------------------------|------------------------------------------------------|------|
| (a)(i)          | <ul style="list-style-type: none"> <li>swollen / enlarged (hands)</li> </ul> | <b>ACCEPT</b> oedema<br><b>IGNORE</b> other symptoms | (1)  |

| Question number | Answer                                                                                                             | Additional guidance                                                                 | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------|
| (a)(ii)         | Any <b>two</b> from: pain / hurts / tender / aches<br>redness / red<br>warmth / heat / increased temperature / hot | <b>IGNORE</b> swelling<br><b>IGNORE</b> immobility / itching<br><b>IGNORE</b> fever | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                           | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | An explanation that includes two of the following points: <ul style="list-style-type: none"> <li>because when the virus replicates the {DNA / gene} will be transcribed (1)</li> <li>and when the RNA is translated the {protein / TNF} will be synthesized (1)</li> <li>TNF incorporated into capsid when virus is assembled (1)</li> </ul> | <b>ACCEPT</b> RNA / mRNA will be made<br><b>ACCEPT</b> description<br><b>ACCEPT</b> when new particles are made<br><b>NB</b> The {gene / DNA} is transcribed and translated = 1 mark if no other mark awarded | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                               | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | An explanation that includes two of the following points: <ul style="list-style-type: none"> <li>antibody {binds to / neutralises / agglutinates} TNF (1)</li> <li>therefore will prevent the TNF from binding to the cells (1)</li> <li>and therefore inflammatory responses will not be triggered (1)</li> </ul> | <b>DO NOT ACCEPT</b> antibody binds to cells / antibody destroys TNF<br><b>IGNORE</b> opsonisation<br><b>DO NOT ACCEPT</b> antibody binds to receptors (on the cells)<br><b>ACCEPT</b> inflammation will {not occur / be reduced} | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>because (as a result of the TNF antibodies binding to TNF) phagocytosis (by macrophages) will {not happen / be reduced} (1)</li> <li>therefore {fewer bacteria will be destroyed / bacteria will increase in number} (if less phagocytosis) (1)</li> <li>credit details of what will not take place if <u>macrophages</u> are impaired (1)</li> <li>therefore tubercles (more likely to) form (1)</li> <li>credit example of how TB can cause death (1)</li> </ul> | <p>e.g. antigen presentation / activation of T helper cells / humoral immune response</p> <p>e.g. destruction of lung tissue / organ failure / opportunistic infection / pneumonia / HIV / lung damage</p> | (4)  |

Q5.

| Question number | Answer                                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                       | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>pain / hurts / tender / aches / throbbing / dolor</li> <li>redness / red / rubor</li> <li>warmth / heat / hot / increased temperature / calor</li> <li>loss of function</li> </ul> | <p>All 3 correct = 2 marks<br/>1 or 2 correct = 1 mark<br/><b>IGNORE</b> itching</p> <p><b>IGNORE</b> rash</p> <p><b>IGNORE</b> fever</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                                                                                                                                      | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• pain alerts the person that there is an injury (1)</li> <li>• warmth speeds up {chemical reactions / skin cell division / phagocytosis / increases rate of enzyme activity (of person) / defence mechanisms} (1)</li> <li>• swelling results in more {blood / white blood cells / platelets / phagocytes / antibodies / tissue fluid} (to the wound) (1)</li> <li>• redness results in more {blood / white blood cells / platelets / phagocytes / antibodies} (to the wound) (1)</li> </ul> | <p><b>NB CE from (i)</b></p> <p><b>ACCEPT</b> to avoid {contact with area /using the injured part}</p> <p><b>ACCEPT</b> reduce activity of bacterial enzymes / reduce growth of bacteria</p> <p>* two different ideas must be given to award 2 marks</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional guidance                                                                                                                                                                                                                                                                                                    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An answer that includes the similarity and two of the three differences:</p> <p>Similarities:</p> <ul style="list-style-type: none"> <li>• (overall) both treatments decrease inflammation (1)</li> </ul> <p>Differences:</p> <ul style="list-style-type: none"> <li>• curcumin is more effective than drug A (throughout) (1)</li> <li>• maximum decrease for drug A is less than that for curcumin(1)</li> <li>• credit a comparison at specific days (1)</li> </ul> | <p><b>DO NOT PIECE TOGETHER</b> but accept in adjacent sentences</p> <p><b>ACCEPT</b> converse where appropriate<br/>turmeric for curcumin</p> <p><b>IGNORE</b> references to rate</p> <p>e.g. inflammation increases {2 / 4} days after operation with drug A but increases after day 3 with curcumin extract (1)</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                            | Additional guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (b)(ii)         | <p>The correct answer is C 33.3 (g)</p> <p><i>A is incorrect because 0.03g contains 0.009g curcumin</i></p> <p><i>B is incorrect because 3.33g contains 0.1g of curcumin</i></p> <p><i>D is incorrect because 33.3 recurring has been rounded incorrectly</i></p> |                     | (1)  |

Q6.

| Question number | Answer                                                                                                                                                                                                      | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | An answer that includes the following points: <ul style="list-style-type: none"> <li>• can differentiate into all cell types (1)</li> <li>• have no Hayflick limit / can divide indefinitely (1)</li> </ul> | (2)  |

| Question number | Answer                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------|------|
| (b)(i)          | B negatively-charged fragments move towards the positive end of the gel | (1)  |

| Question number | Answer | Mark |
|-----------------|--------|------|
| (b)(ii)         | A 1    | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><b>Indicative content</b></p> <ul style="list-style-type: none"> <li>• Bands 1, 2, 5, 9 and 11 in the embryo are also found in the mother</li> <li>• therefore, they must have been present in the nucleus of the egg cell from the mother</li> <li>• Bands 4, 6, 7, 8 and 10 in the embryo are also found in the father</li> <li>• therefore they must have been present in the nucleus of the sperm from the father</li> <li>• Bands 3 and 12 in the embryo are not found in either the mother or the father</li> <li>• therefore they must have been the mitochondrial DNA from the donor</li> <li>• both mother and father have bands not found in the embryo</li> <li>• the bands in the mother could be her mitochondrial DNA</li> </ul> | (6)  |

| Level | Marks | Descriptor                                                                                                                                                                                                                                                                                                                          |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|       | 0     | No awardable content.                                                                                                                                                                                                                                                                                                               |
| 1     | 1-2   | <p>An explanation may be attempted but with limited interpretation or analysis of the scientific information and with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information, with some attempt made to link knowledge and understanding to the given context.</p>       |
| 2     | 3-4   | <p>An explanation will be given, with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning, with some structure.</p>                                                                            |
| 3     | 5-6   | <p>An explanation is made that is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning, which is clear and logically structured.</p> |

Q7.

| Question number | Answer                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                        | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>A calculation showing the following steps:</p> <ul style="list-style-type: none"> <li>1% of 47 278 calculated (1)</li> <li>85.6% calculated and added to 47 278 (1)</li> <li>answer expressed in standard form with between 2 and 5 sig figs (1)</li> </ul> | <p>Example of calculation</p> $1\% = 47\,278 \div 100 = 472.78$ $472.78 \times 85.6 + 47\,278 = 45\,890.928$ $3.28 \times 10^5$ <p><b>NB</b> wrong value correctly expressed in standard form = 1 mark</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>biodiversity could decrease as species {become extinct / number decrease} due to {loss of habitat / decrease in food}</li> </ul> <p><b>OR</b></p> <p>biodiversity could decrease due to as decrease in genetic diversity within a species due to {loss of habitat / decrease in food} (1)</p> <ul style="list-style-type: none"> <li>population could decrease as organisms (of one species) die because there is not enough {food / habitat / camouflage} (1)</li> </ul> | <p><b>ACCEPT</b> territory decrease in species richness<br/><b>IGNORE</b> migration</p> <p><b>ACCEPT</b> territory starve if not enough food<br/><b>IGNORE</b> migration</p> <p>Award 1 mark if biodiversity and population given the wrong way round or rolled in together</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>behavioural because the moths are drinking where the bees drink (1)</li> <li>{anatomical / physical / structural / morphological} because the moths have the {transparent wings / fur} like the bees (1)</li> </ul> | <p><b>ACCEPT</b> blue bands to blend in with the water</p> <p><b>NB</b> two explained adaptations given but not linked to type = 1 mark<br/>one example given for each stated type of adaptation but no link to bees = 1 mark</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                  | Additional guidance                                                    | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>deter predators (as they resemble bees / bees sting) (1)</li> <li>the bees may not attack the moths (1)</li> <li>moths are hidden in amongst the bees whilst drinking (1)</li> </ul> | <p><b>ACCEPT</b> less likely to be eaten as more (insects) present</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                | Additional guidance                                                              | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An answer that includes three of the following points:</p> <ul style="list-style-type: none"> <li>amplify the DNA of both species using PCR (1)</li> <li>use of (gel) electrophoresis (1)</li> <li>credit details of gel electrophoresis (1)</li> <li>compare the DNA <b>bands</b> of the two moths (1)</li> </ul> | <p>e.g. agarose gel, apply a current, use of dye, use of restriction enzymes</p> | (3)  |

Q8.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>antibiotics used to treat impetigo and whooping cough because they are caused by bacteria (1)</li> <li>antibiotics not always used to treat middle ear infections or sinus infections as they {can be caused by viruses / as they are not always caused by bacteria} (1)</li> <li>antibiotics not used to treat multiple sclerosis or rheumatoid arthritis as they are not caused by bacteria (1)</li> </ul> | <p><b>NB Do not accept if clear confusion with antibodies</b></p> <p><b>ACCEPT</b> because some of the bacteria are resistant to antibiotics</p> <p><b>IGNORE</b> any ref to cause</p> <p><b>ACCEPT</b> antibiotics used for bacterial infections if no other marks awarded</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>The only correct answer is <b>B</b>.</p> <p><i>A is incorrect because bactericidal antibiotics decrease the number of bacteria</i><br/> <i>C is incorrect because antibiotics do not increase the number of bacteria</i><br/> <i>D is incorrect because antibiotics do not increase the number of bacteria</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                     | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>to compete with (pathogenic) bacteria for {nutrients /named nutrient / space} (1)</li> <li>so they {reduce / destroy / prevent the growth of}(pathogenic) bacteria (1)</li> </ul> | <p><b>IGNORE</b> food<br/> <b>ACCEPT</b> produce {toxins / chemicals}</p> <p><b>ACCEPT</b> so that they do not increase in number and cause disease</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                 | Additional guidance                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>(because gut flora contain) bacteria (1)</li> <li>and antibiotics are not (generally) specific to one type of bacteria (1)</li> </ul> | <p><b>ACCEPT</b> antibiotics {can affect different types of bacteria / can be broad spectrum}</p> | (2)  |

| Question number | Answer                                                                                                                               | Additional guidance | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (c)(iii)        | <ul style="list-style-type: none"> <li>accept a value between <math>9 \times 10^5</math> and <math>1.2 \times 10^7</math></li> </ul> |                     | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(iv)         | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>antibiotic P kills all but three types (1)</li> <li>antibiotic Q only kills two types (1)</li> <li>antibiotic R has no effect (on gut flora / types A and B) (1)</li> </ul> | <p><b>ACCEPT</b> descriptions in terms of resistance and susceptibility but not immunity throughout</p> <p><b>ACCEPT</b> correct references to bactericidal and bacteriostatic</p> <p><b>ACCEPT</b> kills 4 types / kills type A but has limited effect on type B</p> <p><b>ACCEPT</b> results in the presence of a new type / reduces the number of type A and type B</p> | (3)  |

Q9.

| Question number | Answer                                                                                                                                                                                                                                                                | Additional guidance                                                                                                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because MRSA has developed {antibiotic / methicillin} resistance (1)</li> <li>so we have had to find new drugs that this bacteria is not resistant to (1)</li> </ul> | <p><b>NB ACCEPT</b> pathogens / bacteria throughout</p> <p><b>DO NOT ACCEPT</b> immune for resistance throughout</p> <p><b>ACCEPT</b> spreading / increasing</p> <p><b>ACCEPT</b> that will destroy it</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                              | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>because skin flora {prevent the growth of / destroy / kill} {other bacteria / pathogens} (1)</li> <li>by competing for {space / nutrients} / producing toxins (1)</li> </ul> | <p><b>ACCEPT</b> provide a barrier in protecting the body from infection</p> <p><b>ACCEPT</b> produce lactic acid <b>DO NOT ACCEPT</b> sebum</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                     | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• (if the bacteria are weaker) they will {not reproduce as fast / infect fewer cells} (1)</li> <li>• therefore there will be fewer toxins produced (1)</li> <li>• therefore an immune response will be more effective (1)</li> </ul> | <p><b>ACCEPT</b> descriptions e.g. macrophages will be able to engulf more, more antibodies produced, more T killer cells activated</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                        | Additional guidance                                                                      | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|
| (d)(i)          | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• so that the size of the infection with the solvent could be measured (1)</li> <li>• so that the effect of the drug itself can be determined (1)</li> </ul> | <p><b>ACCEPT</b> to show {the effect of Castaneroxy / that Castaneroxy is effective}</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional guidance                                                                                                                                                                                                                                                                                                                            | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (d)(ii)         | <p>An answer that includes any two of the following points:</p> <ul style="list-style-type: none"> <li>• comment about effect of Castaneroxy on size during time period 0 and 6 days (1)</li> <li>• comment made about Castaneroxy (compared to solvent) on size during time period {0 / 6} and 14 days (1)</li> <li>• comment comparing the two concentrations of Castaneroxy (1)</li> </ul> <p><b>AND</b></p> <ul style="list-style-type: none"> <li>• credit calculation to quantify reduction in size (1)</li> </ul> | <p>e.g. Castaneroxy does not prevent increase in size, the size does not increase as much as the solvent</p> <p>e.g. Castaneroxy reduces mean size</p> <p>e.g. Castaneroxy at high concentration decreases the size more than at lower concentrations, high concentrations clear up the infection completely but low concentrations do not</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                 | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|------|
| (d)(iii)        | <ul style="list-style-type: none"> <li>mass of Castaneroxy A needed in 1 dm<sup>3</sup> calculated (1)</li> <li>mass of leaves needed for 50 000 µg (1)</li> <li>converted into kg and rounded up to 3 (kg) (1)</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>50 µg converted into kg (1)</li> <li>mass needed in 1 litre (1)</li> <li>converted into kg and rounded up to 3 (kg)</li> </ul> | <p>50 000</p> <p>2 631 578 947</p> <p>0.00000005</p> <p>0.00005</p> | (3)  |

Q10.

| Question number | Answer                                                                                                                                                                                                                                                                                                                    | Additional guidance                                                                                                                                                                                                                                                                                                                            | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>nuclear DNA is linear and mtDNA is circular (1)</li> <li>nuclear DNA has unbound {phosphate group / sugar} whereas mtDNA does not (1)</li> <li>mtDNA has (far)fewer {phosphodiester bonds / base pairs} (1)</li> </ul> | <p><b>DO NOT PIECE TOGETHER</b></p> <p><b>IGNORE</b> straight / strands<br/>double helix</p> <p><b>IGNORE</b> shorter / smaller</p> <p><b>ACCEPT</b> other <u>structural</u> difference e.g. nuclear DNA organised around histones whereas mtDNA {is not / organised into nucleoids}<br/>nuclear DNA has 3' and 5' ends but mtDNA does not</p> | (2)  |

| Question number | Answer                                                                                                                                                                                | Additional guidance                                                                                                                                                                                                                    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | Any two from <ul style="list-style-type: none"> <li>• (DNA) primers (1)</li> <li>• (DNA) (mono)nucleotides (1)</li> <li>• {taq / DNA} polymerase (1)</li> <li>• buffer (1)</li> </ul> | <b>NB</b> Three correct = 2 marks, one or two correct = 1 mark<br><br><b>ACCEPT</b> all 4 listed<br><b>IGNORE</b> bases<br><b>DO NOT ACCEPT</b> RNA nucleotides<br><br><b>ACCEPT</b> taq enzyme<br><b>DO NOT ACCEPT</b> RNA polymerase | (2)  |

| Question number | Answer                                                                                                                          | Additional guidance                                                                                                                                                                                                                                             | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <ul style="list-style-type: none"> <li>• length of time calculated for the 35 cycles (1)</li> <li>• 1.38 (hours) (1)</li> </ul> | 4950 (seconds) / 82.5 (minutes) / 1.375 (hours)<br><br>ecf if a given value in {seconds / minutes} is correctly converted into hours with 2 dps<br><br>Bald answer of 1.38 = 2 marks<br>Bald answer of 4950 (seconds) / 82.5 (minutes) / 1.375 (hours) = 1 mark | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional guidance                                                                                                                                                                                                                                                                                                         | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | An explanation that includes the following points: <ul style="list-style-type: none"> <li>• {(high) temperature / 94°C} to {break the H bonds (between the strands) / separate the strands} (1)</li> <li>• {temperature lowered / 54°C} so that primers can attach (1)</li> <li>• {temperature raised (slightly) / 72°C} new (mono)nucleotides can {align / join} to bases (to form two molecules) (1)</li> <li>• {35 / many} cycles so that {several molecules / enough DNA} is made (1)</li> </ul> | <b>ACCEPT</b> temperature lowered if no mention of primers<br><b>ACCEPT</b> appropriate temperature for (DNA) polymerase<br><b>IGNORE</b> bases / strands<br><br><b>IGNORE</b> strands<br><br><b>NB</b> Max 2 marks if no ref to change or quoted temperature from our diagram, provided the steps are in the correct order | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                    | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• by DNA profiling (1)</li> <li>• so that banding patterns (in each crow can be produce) and compared (1)</li> <li>• the more similar the profiles the more closely-related the crows (1)</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>• by DNA profiling (1)</li> <li>• so that base sequences (in each crow can be determined) and compared (1)</li> <li>• the more similar the (base) sequences the more closely-related the crows (1)</li> </ul> | <p>ACCEPT (gel) electrophoresis / description of the process<br/>DNA fingerprint</p> <p><b>IGNORE</b> common ancestor</p> <p>ACCEPT bioinformatics</p> | (3)  |

Q11.

| Question number | Answer                                                                                                                                                                                                                                           | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>The only correct answer is <b>D</b>.</p> <p><b>B</b> is incorrect because all three statements are true<br/> <b>C</b> is incorrect because all three statements are true<br/> <b>D</b> is incorrect because all three statements are true</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                         | Additional guidance                                                                                          | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• attaches to the {malto porin / <i>E. coli</i> / bacteria} (1)</li> <li>• so that the {DNA / genetic material / core} can penetrate into the (bacterial) cell (1)</li> </ul> | <p><b>IGNORE</b> host cell</p> <p><b>DO NOT ACCEPT</b> RNA<br/> <b>IGNORE</b> ref to virus entering cell</p> | (2)  |

| Question number | Answer                                                                                               | Additional guidance                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <ul style="list-style-type: none"> <li>to respire / to make ATP / as an energy source (1)</li> </ul> | <p><b>ACCEPT</b> regulation of gene expression<br/>formation of peptidoglycan<br/><b>DO NOT ACCEPT</b> to make energy</p> <p><b>NB</b> there may be other correct answers that will need checking</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p><b>Points relating to the bacterial cell:</b></p> <ul style="list-style-type: none"> <li>mutation in the {lamB gene / gene coding for maltoprotein}</li> <li>changing the structure of the maltoprotein</li> <li>so that the J protein can no longer {bind / bind as well}</li> <li>mutation resulting in the production of a (new) enzyme</li> <li>that can cleave the J protein off the maltoprotein</li> <li>preventing E. coli from being {infected / destroyed}</li> <li>bacteria that survive will divide (asexually)</li> <li>forming a clone of resistant bacteria</li> <li>presence of virus acting as a selection pressure</li> <li>but the maltoprotein would need to remain functional</li> <li>otherwise no sugars for respiration</li> </ul> <p><b>Points relating to the λ phage:</b></p> <ul style="list-style-type: none"> <li>without being able to attach to the bacteria, the virus will not persist</li> <li>as it needs a host cell to replicate</li> <li>being able to bind is the selection pressure</li> <li>mutation in the viral DNA coding for the J protein</li> <li>that would result in a J protein capable of binding to the altered maltoprotein</li> <li>that would result in a J protein that could bind more strongly to the maltoprotein</li> <li>that would result in binding to another attachment site</li> <li>viruses that can bind will result in production of viruses that can also bind</li> <li>as their genetic material will be cloned inside the host cell</li> </ul> | <p><b>Level 1:</b></p> <p><b>1 mark</b> = 1 relevant comment made</p> <p><b>2 marks</b> = 3 points made</p> <p><b>Level 2:</b></p> <p><b>3 marks</b> = 4 points made that include both virus and bacteria</p> <p><b>4 marks</b> = 5 points made that include both virus and bacteria</p> <p><b>Level 3:</b></p> <p><b>5 marks</b> = 6 points made that include both virus and bacteria</p> <p><b>6 marks</b> = 6 points which include<br/><b>Either</b><br/>the need for the maltoprotein to remain functional</p> <p><b>Or</b><br/>how mutations are passed on to next generation of viruses and bacteria</p> <p><b>NB</b> limited to max 3 marks if no reference made to either J protein or maltoproteins</p> | (6)  |

Q12.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                         | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• microorganisms are (already) involved in the {carbon cycle / decomposition} (1)</li> <li>• because they {produce enzymes (for decomposition) / will be able to produce enzymes for break down of plastics} (1)</li> <li>• mutation occurs (that results in the breakdown plastics) (1)</li> </ul> | <p><b>ACCEPT</b> microorganisms can (already) break down {polymers / organic molecules}</p> <p><b>DO NOT ACCEPT</b> break down plastics</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                      | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• mutation occurs resulting in an enzyme that breaks down plastics (1)</li> <li>• (presence of) {plastics / lack of food} acts as a selection pressure (1)</li> <li>• these {genes / alleles} are passed onto next generation (by asexual reproduction / conjugation / plasmids) (1)</li> </ul> | <p><b>NB</b> this mp can only be awarded if the allele / gene has been linked to breaking down plastics</p> <p><b>IGNORE</b> mitosis</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark       |            |     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|-----|
| (b)             | <p>D</p> <table><tr><td>hydrolysis</td><td>hydrolysis</td></tr></table> <p>The only correct answer is <b>D</b></p> <p><b>A</b> is incorrect because molecules break down by hydrolysis and both reactions are breaking molecules down</p> <p><b>B</b> is incorrect because molecules break down by hydrolysis and both reactions are breaking molecules down</p> <p><b>C</b> is incorrect because molecules break down by hydrolysis and both reactions are breaking molecules down</p> | hydrolysis | hydrolysis | (1) |
| hydrolysis      | hydrolysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |            |            |     |

Q13.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                                                                                                                                 | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>• compete with pathogen for {space / nutrients / metabolites / named nutrient} (1)</li> <li>• (skin flora) producing toxins (to pathogens) (1)</li> <li>• preventing {the growth of the pathogens / colonisation (of the skin) by pathogens} (1)</li> </ul> | <p><b>ACCEPT</b> other {bacteria / microorganisms} for pathogens</p> <p><b>ACCEPT</b> nutrition<br/><b>IGNORE</b> food</p> <p><b>ACCEPT</b> anti-microbials chemicals if linked to mp 3 or qualified as being poisonous<br/><b>DO NOT ACCEPT</b> sebum</p> <p><b>ACCEPT</b> stimulate the immune system (toxins) kill pathogens</p> | (2)  |

| Question number | Answer                                                                                                              | Additional guidance                                                                 | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------|
| (a)(ii)         | <ul style="list-style-type: none"> <li>• keratin / antimicrobial secretions (by the skin) / oils / sebum</li> </ul> | <p><b>ACCEPT</b> barrier<br/><b>IGNORE</b> sweat explanations and other methods</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>majority of bacteria are three types</li> <li>males of all ages have the same (predominant) groups of bacteria present on their skin (1)</li> <li>Proteobacteria are the highest group of bacteria in all age groups (1)</li> <li>middle aged men and elderly men have similar proportions of the three types of bacteria present on their skin (1)</li> </ul> | <p><b>IGNORE</b> reference to 'others' throughout<br/><b>Do not piece together</b></p> <p><b>ACCEPT</b> Firmicutes is lowest named bacteria in all groups</p> <p><b>ACCEPT</b> teenagers have {more Firmicutes and Actinobacteria / less Proteobacteria} (than middle aged and elderly men)</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                            | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>A description that includes two of the following points:</p> <ul style="list-style-type: none"> <li>collect from same part of {body / skin} (1)</li> <li>men should use same washing regime (1)</li> <li>men from same environment (1)</li> <li>men should not be taking antibiotics (1)</li> </ul> | <p><b>ACCEPT</b> description e.g number of showers, same soaps</p> <p><b>ACCEPT</b> same parts of the world, named environmental conditions e.g. UV light, humidity, temperature</p> <p><b>ACCEPT</b> should not use antibacterial {soaps / creams}<br/>no skin conditions</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                               | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>macrophages {engulf / phagocytose / ingest} the bacteria (1)</li> <li>and destroy the bacteria with enzymes (1)</li> </ul> | <p><b>ACCEPT</b> pathogens / microorganisms<br/> <b>DO NOT ACCEPT</b> viruses<br/> <b>DO NOT ACCEPT</b> in context of opsonisation</p> <p><b>ACCEPT</b> digestive enzymes / named digestive enzyme / lysozyme</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>A description that includes two of the following points:</p> <ul style="list-style-type: none"> <li>macrophages present antigen (on surface / on MHC) (1)</li> <li>(macrophages present antigen) to {T helper / CD4} cells (1)</li> <li>macrophage engulf opsonised bacteria (1)</li> </ul> | <p><b>DO NOT ACCEPT</b> to T killer cells / B cells / other cells</p> <p><b>ACCEPT</b> description of opsonisation</p> | (2)  |

Q14.

|        | Answer                                                                                                                                                                                                                                                           | Mark |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i) | <p>The only correct answer is A.</p> <p><i>B is incorrect because TMV does not have an envelope</i><br/> <i>C is incorrect because <math>\lambda</math> phage does not have an envelope</i><br/> <i>D is incorrect because TMV does not have an envelope</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>The only correct answer is C.</p> <p><i>A is incorrect because Ebola has a helical structure</i><br/> <i>B is incorrect because HIV has a polyhedral structure</i><br/> <i>D is incorrect because TMV has a helical structure</i></p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(iii)        | <p>The only correct answer is C.</p> <p><i>A is incorrect because Ebola, HIV and TMV all have RNA and <math>\lambda</math> phage has DNA</i></p> <p><i>B is incorrect because Ebola, HIV and TMV all have RNA and <math>\lambda</math> phage has DNA</i></p> <p><i>D is incorrect because Ebola, HIV and TMV all have RNA and <math>\lambda</math> phage has DNA</i></p> | (1)  |

| Question number | Answer                | Additional guidance | Mark |
|-----------------|-----------------------|---------------------|------|
| (b)(i)          | U G G U U C C G C (1) |                     | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                            | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes two of the following points:</p> <ul style="list-style-type: none"> <li>(because the positive strand) has the {codons / codes} for the {proteins / amino acids} (1)</li> <li>because the positive strand has the complementary base sequence needed to make the negative strand (1)</li> </ul> | <p><b>ACCEPT</b> used in translation / (viral) genes<br/>negative strand does not have the correct codons<br/><b>DO NOT ACCEPT</b> transcription</p> <p><b>IGNORE</b> refs to sense and antisense(strands)</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                                                                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>because (during 18 days) new viruses are produced (1)</li> <li>(new) viruses {burst out of / damage} (host) cells (1)</li> <li>infecting more cells / causing the spread of the virus (1)</li> <li>takes time for the immune system to be stimulated (1)</li> <li>so {person may become ill / virus out of control} before immunesystem stimulated (1)</li> </ul> | <p><b>IGNORE</b> refs to latency / description of retroviruses / replication of DNA</p> <p><b>IGNORE</b> names of host cells</p> <p><b>ACCEPT</b> description of event that takeplace</p> <p><b>ACCEPT</b> description e.g. not enough antibodies present for opsonisation<br/><b>ACCEPT</b> before {receiving antiviral drugs / drugs can take effect}<br/><b>DO NOT ACCEPT</b> kill virus</p> | (4)  |

| Question number | Answer                                                                                                                        | Additional guidance                                          | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------|
| (a)             | <ul style="list-style-type: none"> <li>the larger the {microorganisms / cells} the greater the optical density (1)</li> </ul> | <b>ACCEPT</b> converse<br><b>ACCEPT</b> positive correlation | (1)  |

| Question number | Answer                                                                                                                                        | Additional guidance                            | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|------|
| (b)             | <p>A calculation that shows the following steps:</p> <p>values read from the graph (1)</p> <p>bacteria number divided by yeast number (1)</p> | $0.5 \times 10^6$ and $12.5 \times 10^6$<br>25 | (2)  |

| Question number | Answer                                                                                                                                                                                                                                             | Additional guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| (c)(i)          | <ul style="list-style-type: none"> <li>as the concentration (of bacteria) increases, the optical density increases and then levels off (between <math>15</math> and <math>16 \times 10^6</math> cells per <math>\text{cm}^3</math>) (1)</li> </ul> |                     | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)(ii)         | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>with more cells present there is <b>more</b> reflection of light from the cells (1)</li> <li>some light being reflected away from the detector (1)</li> <li>some light being reflected towards the detector (1)</li> </ul> | <b>ACCEPT</b> scattered / hitting converse<br><br><b>ACCEPT</b> bacteria block the light so that it does not reach the detector<br><br>' at higher concentration the optical density levels off ' = 1 mark if no other marks awarded | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (d)             | <p>A calculation that shows the following steps:</p> <ul style="list-style-type: none"> <li>• numbers substituted into equation (1)</li> <li>• equation rearranged (1)</li> <li>• time given in hours (to a maximum of 3 decimal places) (1)</li> </ul> | <p>Example of calculation</p> $0.963 = (7.079 - 3.778) \div 0.301t$ $0.963 \times 0.301 t = 3.301$ $0.289863 t = 3.301$ <p>CE if log of logs taken</p> $0.963 \times 0.301t = 1994000$ <p>11 / 11.4 / 11.39 / 11.388 (hours)</p> <p>CE if log of logs taken 41378168 hours</p> <p><b>ACCEPT</b></p> <p>11 hours = 660 minutes<br/> 11.4 hours = 684 minutes<br/> 11.39 hours = 683.4 minutes<br/> 11.388 hours = 683.28 minutes</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| * (e)           | <p>Indicative content:</p> <ul style="list-style-type: none"> <li>• some organisms are larger than others</li> <li>• light more likely to hit a larger organism and be reflected</li> <li>• therefore optical density will be higher</li> <li>• photometers are designed differently</li> <li>• light may have further to travel through the organisms</li> <li>• so is more likely to be reflected back</li> <li>• decreasing optical density</li> <li>• concentration of organisms affects the optical density</li> <li>• so different calibration curves may be necessary for higher concentrations</li> <li>• the light absorbance is specific to the organism</li> <li>• and therefore will affect the absorbance value</li> </ul> <p>Level 1 :<br/> 1 mark = 1 comment<br/> 2 marks = 2 comments</p> <p>Level 2 :<br/> 3 marks = 3 comments that includes 1 description / explanation<br/> 4 marks = 4 comments that includes 1 description / explanation</p> <p>Level 3 :<br/> 5 marks = 5 comments that includes 2 description / explanation<br/> 6 marks = 6 comments that includes 2 description / explanation</p> |                     | (6)  |

Q16.

| Question number | Answer                                                                             | Additional guidance                                                                                                     | Mark |
|-----------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <ul style="list-style-type: none"> <li>83 / 83.0 / 83.3 / 83.33 (%) (1)</li> </ul> | <b>DO NOT ACCEPT</b> any other values including recurring numbers e.g. $83.\dot{3}$<br><b>IGNORE</b> {decrease / - / ↓} | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| *(b)(i)         | <p><b>Table:</b></p> <ul style="list-style-type: none"> <li>Tasmanian devils spend less time feeding in cancer areas (D)</li> <li>because there are fewer Tasmanian devils in these areas (E)</li> <li>because they have died from the cancer (E)</li> <li>because they are sick and get chased away by the other scavengers (E)</li> <li>because they are sick and have lost their appetite (E)</li> <li>{ravens / quolls / cats} all spend longer feeding in cancer areas (D)</li> <li>because there are fewer Tasmanian devils (E)</li> <li>therefore more food to go round / less competition (E)</li> <li>because there are fewer Tasmanian devils to frighten them away (E)</li> <li>because sick Tasmanian devils are too ill to chase scavengers away (E)</li> <li>ravens, quolls and feral cats in similar proportions in both areas (D)</li> <li>because they eat different parts of the carcass (E)</li> <li>so are not in competition with each other (E)</li> </ul> <p><b>Graph:</b></p> <ul style="list-style-type: none"> <li>carcasses in cancer areas are lasting longer than those in the healthy area (D)</li> </ul> | <p><b>ACCEPT</b> converse throughout where appropriate</p> <p><b>Level 1:</b></p> <p>1 mark = one description only</p> <p>2 marks = two descriptions<br/> <b>OR</b><br/>         one simple explanation</p> <p><b>Level 2:</b></p> <p>3 marks = more than one explanation from either table or graph</p> <p>4 marks = explanations for both table and graph</p> <p><b>Level 3:</b></p> <p>5 marks = explanations for both table and graph, one of which is extended</p> <p>6 marks = to include extended explanations for both table and graph</p> | (6)  |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                  |  |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--|
|  | <ul style="list-style-type: none"> <li>• because there are fewer Tasmanian devils to feed on the carcass (E)</li> <li>• because they are sick and have lost their appetite (E)</li> <li>• because scavengers do not eat as fast as Tasmanian devils (E)</li> <li>• because scavengers do not eat all the carcasses (E)</li> <li>• but they eventually breakdown by {decomposers / other scavengers} (E)</li> </ul> | <b>NB</b> Extended explanation either offers two alternative explanations or has two steps to it |  |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--|

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                       | Mark       |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| (b)(ii)         | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>• (type or number) {microorganisms / insect species} that decompose the carcasses (1)</li> <li>• other species of scavengers as they would also feed on the carcasses (1)</li> <li>• people as this could frighten away the {scavengers / Tasmanian devils} (1)</li> <li>• other predators because they could affect the number of {scavengers / Tasmanian devils} feeding (1)</li> <li>• pathogens as they could affect the number of {scavengers / Tasmanian devils} feeding (1)</li> </ul> | <p><b>ACCEPT</b> competing for carcass</p> <p><b>ACCEPT</b> named activity of people and the effect</p> <p><b>NB</b> If no marks awarded, allow 1 mark for a named biotic factor from the mark scheme</p> | <b>(4)</b> |

Q17.

| Question number | Answer                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                   | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>• {(genetic) code / genetic material / genetic information / genes} for {(viral) proteins / amino acid sequence} (1)</li> <li>• credit a named example from the diagram (1)</li> </ul> | <p><b>IGNORE</b> references to transcription, DNA and RNA synthesis</p> <p>e.g. RNA polymerase, VP 40<br/><b>ACCEPT</b> glycoproteins / protein coat / capsid</p> <p>'carry the genetic code for the proteins shown in the diagram'<br/>= 2 marks</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                           | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• attach to the host cell (1)</li> <li>• by binding to (specific) receptors (1)</li> <li>• avoid host's immune system (1)</li> </ul> | <p><b>ACCEPT</b> {liver / endothelial / immune} cells</p> <p><b>ACCEPT</b> molecules / antigens / glycoproteins / TIM-1</p> <p>'bind to receptors on host cell' = 2 marks</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                              | Additional guidance                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• to make (viral) RNA / transcription (of viral RNA) (1)</li> <li>• because the host cell does not have this enzyme (1)</li> </ul> | <p><b>ACCEPT</b> mRNA<br/><b>DONOT ACCEPT</b> to make DNA / protein</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                | Additional guidance                                                                                      | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An answer that includes the following points:</p> <ul style="list-style-type: none"> <li>• (assembling) {RNA/ (viral) <b>genome</b>} and <b>proteins</b></li> <li>• to make a (new) virus particle (1)</li> <li>• credit example given from diagram (1)</li> </ul> | <p><b>IGNORE</b> envelope</p> <p>e.g. VP 40 incorporated into the capsid, RNA enclosed in the capsid</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                           | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (d)             | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• interferon is involved in the non-specific response (against viruses) (1)</li> <li>• therefore (if no interferons are produced) the host cells will not be protected from infection with Ebola (1)</li> </ul> | <p><b>NB ACCEPT</b> converse where appropriate</p> <p><b>ACCEPT</b> inhibits viral replication<br/>named examples<br/>e.g. stimulates production of protein kinase, reduced protein synthesis, stimulates destruction of RNA, stimulates host cell (self) destruction, increases MHC I antigens on host cells, increases recognition of host cells by T killer cells</p> <p><b>DONOTACCEPT</b> {specific/immune response}</p> <p><b>ACCEPT</b> virus can {spread/infect other cells}</p> <p><b>DONOTACCEPT</b> virus being killed or dying throughout<br/><b>IGNORE</b> interferons prevent binding of virus to host cells throughout</p> | (2)  |

| Question number | Answer       | Mark |
|-----------------|--------------|------|
| (a)             | B fatty acid | (1)  |

| Question number | Answer                                                                                                    | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>• bacteria make cell walls only following cell division</li> </ul> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                             | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• if there is no mycolic acid the lysozymes will be able to digest the bacteria (1)</li> <li>• therefore antigens will be produced (1)</li> </ul> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• if there is no mycolic acid in the cell wall, they will be more susceptible to lysozyme action (1)</li> <li>• the membrane structure will be affected (1)</li> <li>• therefore the cell will lose control of molecules entering and leaving (1)</li> </ul> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                               | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iv)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>• transcription will be inhibited (1)</li> <li>• therefore bacteria will not be able to synthesise proteins (1)</li> <li>• therefore {structure / function} of cell will be affected (1)</li> </ul> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(v)          | <p>An explanation that includes any two of the following points:</p> <ul style="list-style-type: none"> <li>• greater exposure to antibiotics increases chances of resistance (1)</li> <li>• therefore bacteria could become resistant to a greater number of antibiotics (1)</li> <li>• greater chance that patients will not take antibiotics correctly (1)</li> </ul> | (2)  |

Q19.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(i)          | <p>The only correct answer is <b>B</b>.</p> <p><b>A</b> is incorrect because nuclei, Golgi apparatus and mitochondria are organelles surrounded by membrane</p> <p><b>C</b> is incorrect because nuclei, Golgi apparatus and mitochondria are organelles surrounded by membrane</p> <p><b>D</b> is incorrect because nuclei, Golgi apparatus and mitochondria are organelles surrounded by membrane</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                                                       | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)(ii)         | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>it is not a plant because it has glycogen granules (1)</li> <li>it is not an animal because it has a cell wall (1)</li> <li>it is not a bacterium because it has {nuclei / Golgi apparatus / mitochondria / membrane-bound organelles} (1)</li> </ul> | <p><b>ACCEPT</b> does not have cellulose cell wall</p> <p><b>IGNORE</b> chloroplast / vacuole</p> <p><b>IGNORE</b> flagellum / pili / capsule / ER</p> <p><b>DO NOT ACCEPT</b> ribosomes / cytoplasm / glycogen granules / cell membrane / cell wall unless qualified as {chitin / not peptidoglycan}</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                      | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)             | <p>An explanation that includes four of the following points:</p> <ul style="list-style-type: none"> <li>there is a correlation between the number of prescriptions and the percentage of resistant <i>E.coli</i> (1)</li> <li>the use of aminopenicillin acts as a selection pressure (1)</li> <li>therefore the resistant bacteria reproduce and the non-resistant bacteria die (1)</li> <li>percentage of resistant <i>E. coli</i> falls when prescriptions fall because non-resistant <i>E. coli</i> are not destroyed (1)</li> <li>credit a comment about competition between resistant and non-resistant bacteria (1)</li> </ul> | <p><b>ACCEPT</b> pattern / trend</p> <p><b>IGNORE</b> directly proportional</p> <p><b>ACCEPT</b> therefore the resistant bacteria {are <b>more</b> likely to reproduce / reproduce <b>more</b>}</p> <p><b>ACCEPT</b> as the prescriptions go up the number of resistant bacteria go up <b>and</b> when the prescriptions go down the number of bacteria go down for 1 mark if no other marks awarded</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                                      | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An explanation that includes three of the following points:</p> <ul style="list-style-type: none"> <li>because the codes of practice (regarding the prescription of antibiotics) are being ignored (1)</li> <li>use of antibiotics is a selection pressure (1)</li> <li>therefore the number of antibiotic resistant bacteria is increasing (1)</li> <li>our (current) antibiotics may become useless and people will {remain ill / die} (1)</li> </ul> | <p><b>ACCEPT</b> (medical) advice</p> <p><b>ACCEPT</b> reference to evolutionary race in an appropriate context<br/>natural bacterial flora destroyed by antibiotics</p> | (3)  |

Q20.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                              | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>A description that includes four of the following points:</p> <ul style="list-style-type: none"> <li>vaccine contains an {inactive / attenuated} form of the {pathogen / virus / bacteria / microorganism} (1)</li> <li>macrophages engulf and display antigen on cell surface (1)</li> <li>macrophages will present the antigen to T helper cells(1)</li> <li>T helper cells will activate {B / T killer} cells (1)</li> <li>(T / B) memory cells produced (1)</li> </ul> | <p><b>ACCEPT</b> antigen (found on the pathogen) / weakened pathogen<br/><b>DO NOT ACCEPT</b> dead {virus / antigen}</p> <p><b>ACCEPT</b> macrophages become antigen-presenting cells + description to T helper cells</p> <p><b>ACCEPT</b> description e.g. T helper cells release cytokines that cause B cell proliferation</p> | (4)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <p>A description that includes the following points:</p> <ul style="list-style-type: none"> <li>• conclusion relating trust in scientists to income (1)</li> <li>• conclusion relating trust in scientists to vaccine safety(1)</li> <li>• conclusion relating income to vaccine safety (1)</li> </ul> | <p>e.g. trust goes down (slightly) with increase in income</p> <p>e.g. people who agree that vaccines are safe trust the scientists the most</p> <p>e.g. at all incomes, there are people who agree, neither agree nor disagree and disagree that vaccines are safe</p> | (3)  |

| Question number | Answer                                                                                      | Additional guidance                                                                                                                                                                                                                                   | Mark |
|-----------------|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>education / (influence of) {media / family / friends / internet} / religious beliefs</p> | <p>previous experiences with {vaccines / medications}</p> <p>ethical beliefs</p> <p>fear of needles</p> <p>lack of trust in testing process</p> <p>allergies</p> <p>side effects</p> <p>more money for {treatment / healthcare} medical insurance</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                     | Additional guidance                                                                                                                                    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (c)             | <p>An answer that includes two of the following points:</p> <ul style="list-style-type: none"> <li>• vaccinated people will {not / be less likely to} develop the disease / vaccinated people will be immune (1)</li> <li>• fewer infected people to infect people who are not immune(1)</li> <li>• protect people who cannot become immune (1)</li> </ul> | <p><b>IGNORE</b> less likely to be infected</p> <p><b>ACCEPT</b> herd immunity</p> <p>e.g. allergic to vaccines, immunodeficient, immunosuppressed</p> | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (a)             | <p>The only correct answer is <b>C</b> lambda phage (<math>\lambda</math> phage)</p> <p><b>A</b> is incorrect because Ebola virus infects humans</p> <p><b>B</b> is incorrect because the HIV infects humans</p> <p><b>D</b> is incorrect because TMV infects plants</p> | (1)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                              | Additional guidance                                          | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------|
| (b)(i)          | <p>A description that includes two of the following points:</p> <ul style="list-style-type: none"> <li>provide a {polar / hydrophilic} channel (1)</li> <li>so that lysins can pass through the {non-polar / hydrophobic} {membrane / phospholipids / fatty acid tails} (out of cell) (1)</li> <li>down their concentration gradient (1)</li> </ul> | <b>IGNORE</b> direction of movement with respect to the cell | (2)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                   | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <p>An explanation that includes three of the following points:</p> <ul style="list-style-type: none"> <li>primary structure is the sequence of amino acids that will determine the (tertiary) structure of {holin / protein} (1)</li> <li>as this will determine the {bonds / position of bonds} (1)</li> <li>(amino acids with) polar R groups will face into the channel (1)</li> <li>(amino acids with) non-polar R groups will face outwards to the {fatty acids / phospholipids / membrane} (1)</li> </ul> | <p><b>PIECE TOGETHER</b><br/><b>DO NOT ACCEPT</b> bases</p> <p><b>ACCEPT</b> correctly named bond</p> | (3)  |

| Question number | Answer                                                                                                                                                                                                                                                                                                   | Additional guidance                                                                                                                                       | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(iii)        | <p>An explanation that includes the following points:</p> <ul style="list-style-type: none"> <li>lysins break bonds between the {peptidoglycan / murein} molecules (1)</li> <li>therefore the virus particles {leave the bacterial cells / get (out) through the cell wall} (once formed) (1)</li> </ul> | <p><b>ACCEPT</b> are enzymes that breakdown {peptidoglycan / murein}</p> <p><b>ACCEPT</b> causing {bacterial cells to burst / pores in the cell wall}</p> | (2)  |

Q22.

| Question number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                |          |                    |                       | Mark      |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------|-----------------------|-----------|-------|--|--|--|------------|----------|--------------------|-----------------------|-----|-----|-----|-----|-----|----------------|-----|-----|-----|-----|----------|-----|-----|-----|-----|-----|
| (a)             | <table><tr><th rowspan="2">Structure</th><th colspan="4">Virus</th></tr><tr><th>Ebola only</th><th>HIV only</th><th>both Ebola and HIV</th><th>neither Ebola nor HIV</th></tr><tr><td>DNA</td><td>[x]</td><td>[x]</td><td>[x]</td><td>[x]</td></tr><tr><td>helical capsid</td><td>[x]</td><td>[x]</td><td>[x]</td><td>[x]</td></tr><tr><td>envelope</td><td>[x]</td><td>[x]</td><td>[x]</td><td>[x]</td></tr></table> |          |                    |                       | Structure | Virus |  |  |  | Ebola only | HIV only | both Ebola and HIV | neither Ebola nor HIV | DNA | [x] | [x] | [x] | [x] | helical capsid | [x] | [x] | [x] | [x] | envelope | [x] | [x] | [x] | [x] | (3) |
| Structure       | Virus                                                                                                                                                                                                                                                                                                                                                                                                                 |          |                    |                       |           |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |
|                 | Ebola only                                                                                                                                                                                                                                                                                                                                                                                                            | HIV only | both Ebola and HIV | neither Ebola nor HIV |           |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |
| DNA             | [x]                                                                                                                                                                                                                                                                                                                                                                                                                   | [x]      | [x]                | [x]                   |           |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |
| helical capsid  | [x]                                                                                                                                                                                                                                                                                                                                                                                                                   | [x]      | [x]                | [x]                   |           |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |
| envelope        | [x]                                                                                                                                                                                                                                                                                                                                                                                                                   | [x]      | [x]                | [x]                   |           |       |  |  |  |            |          |                    |                       |     |     |     |     |     |                |     |     |     |     |          |     |     |     |     |     |

| Question number | Answer                                                                          | Additional guidance                                                                                                                                                       | Mark |
|-----------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| (b)(i)          | <ul style="list-style-type: none"> <li>• (RNA) reverse transcriptase</li> </ul> | <p><b>ACCEPT</b> RNA-dependent DNA polymerase<br/>DNA nucleotidyltransferase<br/>(RNA-directed) revertase</p> <p><b>DO NOT ACCEPT</b> other named enzymes / molecules</p> | (1)  |

| Question number | Answer                                                                                                                                            | Additional guidance                                                                          | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------|
| (b)(ii)         | <ul style="list-style-type: none"> <li>• (this DNA polymerase found in cancer cells) so healthy cells will not be affected by the drug</li> </ul> | <p><b>ACCEPT</b> so that DNA synthesis will not occur and the cancer cells cannot divide</p> | (1)  |